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DELIVERABLE REPORT

D3.2

Performance framework

Version 2.2

JUXTALEARN
Juxtapositioned reflective performance
enabling science and technology learning

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SUMMARY

This deliverable, D3.2, for Work Package 3 incorporating the pedagogy from WP2 and orchestration factors mapped in D3.1 reviews aspects of performance in the context of participative video making. It reviews literature on curiosity and engagement characteristics of interaction mechanisms for public displays and anticipates requirements for social network analysis of relevant public videos from WP6 task 6.3. Thus, to support JuxtaLearn performance it proposes a reflective performance framework that encompasses the material environment and objects required, the participants, and the knowledge needed.

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D3-2 Performance framework

1 Introduction

The aim of this deliverable is to provide an overarching reflective performance framework for the JuxtaLearn process, including the orchestration of performance in-situ issues, and systems to support scaffolding science and technology video performances, with ethical consideration.

The performance framework builds on D3.1, which mapped in-situ performance factors in science and computing educational videos. This deliverable relates orchestration factors to frameworks that will support learning of STEM subjects. Starting from an examination of performance as an enabler for reflective learning, it identifies how best to produce the JuxtaLearn performing process, incorporating factors of curiosity and engagement, and the description of work requires it to anticipate multimedia display documentation. This framework emphasises features that are essential for reflecting on performance and guiding a successful JuxtaLearn performance process.

To support this balancing act, we propose a framework that scaffolds the performance to make threshold concepts easier to learn, to support and build up trust, a framework to support the learning until the student is able to work alone, i.e. the scaffolds will slowly fade out taking into account the increasing expertise of the students (cf. Pea (2004)). The specification of this scaffold for science and technology video performances will be part of a future deliverable, D3.3.

This document is divided into the following sections:

Section 1 “Introduction”: provides a description of the structure and scope of this document.

Section 2 “Orchestration of JuxtaLearn performance for STEM subjects”: examines the juxtaposition of expressing a difficult STEM topic in a different medium, whilst engaging in creative activity. It identifies components of performance that need to be orchestrated for the JuxtaLearn process.

Section 3: JuxtaLearn framework for systems to support STEM subjects: outlines a framework to scaffold orchestration of participants, environment and knowledge.








Section 4: “Conclusion”: concludes by looking at the orchestration factors and their relationships to the required eight steps JuxtaLearn framework.

1.1 List of Acronyms

CM	Catcher Media Ltd
DoW	Description of Work
EC	European Commission
LNU	Linneuniversitetet
OF	Orchestration factor

OU	The Open University
RIAS	Rhein-Ruhr Institut Fur Angewandte Systeminnovation
TC	Threshold Concept
UMINHO	Universidade Do Minho
UOB	University of Birmingham
URJC	Universidad Rey Juan Carlos
VSCL	Video supported collaborative learning
WP	Work Package

1.2 JuxtaLearn Project Partners

JUXTALEARN partner		Organisation name	country code
01	 The Open University	THE OPEN UNIVERSITY	UK
02	 Linnæus University Sweden	LINNEUNIVERSITETET	SE
03	 Rhein-Ruhr Institut für angewandte Systeminnovation e.V.	RHEIN-RUHR INSTITUT FUR ANGEWANDTE SYSTEMINNOVATION	DE
04	 UNIVERSITY OF BIRMINGHAM	THE UNIVERSITY OF BIRMINGHAM	UK
05	 Universidad Rey Juan Carlos	UNIVERSIDAD REY JUAN CARLOS	ES
06	 Universidade do Minho	UNIVERSIDADE DO MINHO	PT
07	 CATCHER MEDIA	CATCHER MEDIA LTD	UK

2 Orchestration of JuxtaLearn performance for STEM subjects

This section discusses two possibly conflicting socio-cognitive activities: understanding and re-presenting a complex abstract topic in a different medium, and engaging in playful creative activity. These two activities may be reconciled through the juxtaposition of scientific learning of STEM topics with creating videos. This is the aim at the heart of the JuxtaLearn project: to juxtapose scientific learning with artistic creation: “to engage students in science and technology learning through ‘reflective performance’ and enhance their personal conceptual understanding through ‘JuxtaLearn’ systems” (DoW, 2012-07-20, part B p 52). Work package 3’s objective is “to understand the relationship between engagement and performance factors in public science and computing educational videos” (DoW, 2012-07-20 Annex A p 12). This objective requires a framework that exploits performance.

For this work package, two types of performance have to be distinguished. First, performance can be defined by measuring the quality of the outcome as is done in assessment centres. This definition encompasses the direct learning outcomes (examination results, increase of knowledge) as well as the reception by the audience, e.g. ratings by other users in social media platform. Second, performance is taken (as in D3.1) to mean performing in the sense of “dramatic playing” that assumes students intend to communicate with an audience (Bolton, 1984). For the JuxtaLearn process, students produce a performance with the intention to communicate their understanding of a STEM threshold concept with an audience. This kind of performance entails enactment, recital, or presentation, which requires orchestration.

The term “to orchestrate” has a dual meaning, in one sense meaning to plan, arrange or score a composition, and in another sense meaning to configure and adjust dynamically, on the fly. Yet the meanings overlap in, for example, that both imply a sense of harmonising activities, and both anticipate some sort of planning action. In the context of (drama) performance, Fuller and Magerko (2011) use the term 'orchestration' to mean performance that "involves intricate orchestration of emotional expressions, communication, interaction strategies, and problem-solving" (Fuller and Magerko, 2011 p269).

However, in the classroom context Dillenbourg (2008) defines orchestration as the interplay of individual, collaborative and class-wide learning activities. This definition refers to how “a teacher manages, in real time, multi-layered activities in a multi-constraints context” (Dillenbourg, 2013).

From the managerial view of being an orchestrator, both concepts of orchestration seem very similar, but the distribution of roles and therefore the activity characteristics have significant differences. The orchestrator in a learning process is the teacher. The teacher decides the location (often classroom, sometimes external locations like museums), the sequencing (lesson plan) and the equipment (e.g. text material, available lab equipment) provided to the learners and in collaborative scenarios about the (re-)grouping of the students. With this responsibility comes the need for solving everyday problems (re-arrangement of groups due to sickness, repetition of necessary pre-knowledge), which are the cause of the multi-constraints and real-time adaption of the initially planned process. Looking at the JuxtaLearn process and especially at the video performance part, the orchestration is expected to be conducted by the students. While the teacher may still be responsible for providing the assets needed for the video (like a producer for movies) and has to structure the overall process (i.e. the overall JuxtaLearn process), the actual video performance has to be directed and prepared (i.e. creating a storyboard, writing a script) by the students. In this context of orchestration, the teacher becomes a moderator of the (drama) performance process.

In the JuxtaLearn process it is important to consider and support both types of orchestration, as the teacher needs some support while orchestrating the JuxtaLearn learning process (i.e. monitoring tools (e.g. Jermann, Soller,

Mühlenbrock, 2001 (2001)) and the students need support while conducting the respective video creation activities. One way of integrating both strands of orchestration is to integrate the video performance (orchestrated by the students) conceptually as an activity within a surrounding learning process (e.g. the JuxtaLearn process) to be orchestrated by a teacher.

One important aspect of the overall management process linked to orchestration from a teacher's perspective is motivating the students to engage themselves with respect to the learning topic. "Students' engagement and motivation are often more intrinsic to the creative disciplines than to STEM subjects" (DoW, 2012-07-20, part B p3). Low motivation and curiosity in STEM subjects risk disengagement and misunderstandings (DoW, 2012-07-20, part B p4). Extrinsic motivation comes about through outside forces such as the likelihood of a good grade or money persuading someone to get something done. Intrinsic motivation is created through internal factors: a desire to know, interest in something, a skill that someone wants to master, or desires to discover, being curious. An apparently anomalous event can challenge intellectual curiosity. Dewey (1933) describes washing glasses in soapsuds, placing them mouth downward and noticing bubbles appear on the outside that then went inside. This experiment aroused his curiosity, giving rise to abstract thought.

The JuxtaLearn process requires an impetus to arouse intellectual curiosity in STEM subjects. Curiosity might be considered "the strong intrinsic desire we living beings have to know or learn something" (Tieben et al., 2011). Tieben et al, relate curiosity to motivation, as a motivator for behaviour, as well as a design element in the world of game-design and a process that iterates over encountering, exploring, discovering and adjusting. Stages of curiosity have been identified as physical, social and intellectual (Dewey, 1933). At a physical level in the younger child, curiosity might be manifested through energy; at a later stage, social stimuli might influence curiosity; and at a higher stage, observation that provokes problems might influence intellectual curiosity (Dewey, 1910). According to Dewey, "The curious mind is constantly alert and exploring" (Dewey, 1910 p31), and can be provoked by unease and by "varied and subtle challenges" (Dewey, 1910 p33).

The STEM teacher is central to orchestrating events that challenge. Different stages at which to arouse curiosity include at the start of the project to get the students going and at screening time to arouse audience interest.

An important aspect of motivation in relation to groups of students working in collaboration is an agreed set of goals, so a group's goal comes before individual interests. Group coherence can improve in the face of an external threat and competition between groups can stimulate their work. Blazek & Hraňová (2012) noted in groups of young students creating PV that they could get problems working together, but rotating roles - director, actor, script writer ameliorated this. One way was to create more outputs to ensure every student could be involved. Another way to deal with differences was to organise the process so that opposing groups coordinated different activities rather than conflict (Blazek and Hraňová, 2012).

A question is to identify how the STEM teacher motivates collaborative work in performance. What are the ways to motivate? Wonder, challenge, debate, parables, and personal relevance are some ways to engage interest. Modes of pedagogy that demand explanations include for example,

- Inquiry learning – an approach that involves learners asking questions, exploring the natural world, discovering and testing discoveries (Scanlon et al., 2012)
- Reciprocal teaching – where students and tutors take turns to lead a dialogue (Palincsar and Brown, 1984)
- Problem based learning – uses problem solving strategies and subject knowledge
- Learning through drama – using drama, not to produce plays, but to expand awareness, enabling students "to look at reality through fantasy" (Wagner, 1979 p 15)

A performance palette would offer a variety of genres that reflect these modes, such as commentary, debate, tutorial, film proposal (treatment), diary, story, games. See also D3.1

For example, mystery stories are *one* means to engage student interest because they have to have a solution, "a need for closure" to bring the "ah-ah" moment that follows the "huh?" Applying this to JuxtaLearn performance requires that the JuxtaLearn videos present mysteries, an approach where even the very title engages interest and entices the audience. Cialdini (2005) argues that mystery is an "underused pedagogical device" (Cialdini, 2005 p22), asserting that mystery stories are pedagogically superior because they demand explanations and creating explanations requires exploring a mystery, homing in by considering alternatives, giving clues, resolving, drawing implications. Were students to create a video following this sequence, then, by Cialdini's argument, it should engage its audience. On the other hand, mystery stories may be pedagogically constrained because they typically provide pre-prepared answers or explanations, rather than engaging the learner in finding the solution.

Engagement requires arousing participants' interest to the point where people are absorbed in the activity, and are in the flow (Csikszentmihalyi, 1990). Aspects of engagement might require both curiosity to initiate engagement, and flow through the process to maintain engagement. In addition, students might be engaged in different aspects of the JuxtaLearn process: in the STEM subject, in the flow of dramatic performance or in the technology-mediated process of video production. These aspects might be in tension, where for example, the focus is on the technical processes of video production as it may be the first time the technology is introduced, or conversely, students being caught up in dramatic performance. Such tension can detract from meaning making and requires orchestrating technology and performance activities, the assumption being that engagement in the creative process affords learning and performance.

The JuxtaLearn process requires reflective performance. Performance requires scriptwriters, director(s) and actors, who all participate in creating the video and its concomitant products such as storyboard and scripts. Participatory video making also involves an audience greater than a single teacher, because in the creation process participants observe fellow participants, their directing, producing and acting, their storyboarding and script writing. Reflective performance requires, not only orchestrating emotional expressions, communication, interaction strategies, and problem solving, but also reflecting on both the process and the threshold concept that the students are learning. Consecutive thoughts that arise during the performance process allow untangling of ideas (Dewey, 1933).

The JuxtaLearn process adds a performance making aspect that requires participants and a suitable environment with materials that afford collaborative learning and participative performance. In addition, when orchestrating the process, teacher STEM knowledge is required. See Figure 1 - Inputs to JuxtaLearn process.

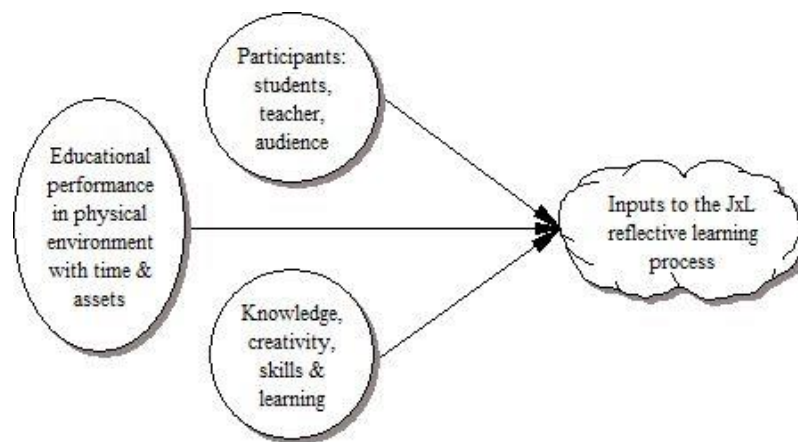


Figure 1 - Inputs to JuxtaLearn process

Taking these conditions as input to the JuxtaLearn process, in the following sections we will discuss people, the performance environment, and knowledge and learning. We will identify environmental material features and objects used in the context of a JuxtaLearn video making process whose steps identify, demonstrate, interpret, perform, edit, share, discuss and review. Objects of the first three steps relate to STEM threshold concepts. Objects of the middle steps also include those related to video creation. The final steps return to share threshold concepts through the video related objects. We will discuss types of knowledge and knowledge transfer as part of the learning process, identify barriers at knowledge boundaries and show how objects that are part of the video-making process can help breach knowledge boundaries.

2.1 Classroom orchestration

The JuxtaLearn process may take place over several teaching periods, days and, in some schools, over several weeks.

Participative video (PV) making is mandatory to the JuxtaLearn process, and student participation is essential to it. Apart from the video making itself, the JuxtaLearn process involves the students in project management activities like structuring the work, deciding on the assignment of roles (e.g. director, script writer etc. - see below) that are vital to a video making process within the group and scheduling of milestones etc. Especially if the students are confronted with such a complex process for the first time, they need support to be able to conduct the whole process and to be able to reflect on their performance.

One way of providing support is the use of collaborative scripts (like the ArguGraph, JigSaw-Designs etc (Dillenbourg et al., 2007). Scripts like these explicate the roles, sequence of activities, specify the activities and necessary resources and their representation (Kollar et al., 2006). These scripts can be used as a scaffold to guide the students' work, by providing them with a structure that needs to be filled (i.e. assigning roles, creating specific resources) by the students. Thus, scripts may provide a template for the managing of their work during the video creation process.

The use of scripts does not only support the students. Especially scripts with an external representation can also support the teachers' lesson planning (Harrer and Malzahn, 2006), the monitoring of processes (Malzahn et al., 2008) and they enable the teachers to discuss their teaching strategy (Harrer and Malzahn, 2006). The JuxtaLearn process already provides a macro script (cf. Dillenbourg (2008) as an orientation for the teacher breaking down the whole process in phases and providing pre-requisites like the taxonomy of threshold concepts, which are used as a means for meaningful support. These mechanisms as basic guidance through the process for the students will not be

enough (Mayer, 2004) and specific guidance (like the pedagogical palette; D2.1) is needed to have an effect on the learning outcome (Van Joolingen and De Jong, 1991)).

Guidance for participating students is just one ingredient for good performance in the JuxtaLearn process. Another group of people needing support are the teachers (Krajcik et al., 1994)). The basic idea of the video performance part of the JuxtaLearn process is very similar to that of project-based learning (Krajcik et al., 1994):

1. Engage students in investigating an authentic question or real world problem that drives activities and organizes concepts and principles [driving questions]
2. Result in students developing a series of artefacts, or products that address the question/problem.
3. Allow students to engage in investigations
4. Involve students, teachers and members of the society in a community of inquiry as they collaborate about the problem
5. Promote students' learning using cognitive tools

As Krajcik et al. (1994)) point out, the teachers need to be supported during a project based teaching approach, because the difficulties they may encounter will otherwise hinder the adoption of the new approach. One example mentioned by Krajcik et al. (1994) of such a difficulty is formulating an appropriate question for the students to elaborate on. The JuxtaLearn approach supports the teacher w.r.t to this issue by providing a taxonomy of threshold concepts (D2.1) and asks them to think of other potential stumbling blocks, which in turn may be used as problem/question for the students' process. While the students are planning for and working on their specific video performance, the teachers have to help all groups to work productively, i.e. they have coordinate the students where necessary, help the students with their topic related questions and keep them motivated and engaged. One support mechanism for this part is to provide awareness tools that help the teachers to keep informed about the progress of the students. Therefore, the learning analytics toolbox (D6.2) will provide awareness tools for that. Of course, contextual factors like available technology (video editing facilities, space and time) will have to be considered. Work package 4 will provide a set of video editing tools and work package 6 (D6.1) will provide a web platform that allows for the sharing of video material within the group and to publish the final videos at the end of the JuxtaLearn process.

2.2 Performance orchestration

Drama performance requires people, often a group of people, usually actors. However, performance requires more team effort than just acting because people orchestrate context and script, communicating and problem solving. Performance combines four participant roles: actors, director, scriptwriter and audience, allowing actors, directors, scriptwriters and audience collaboratively to produce a performance. Different roles come into prominence at different stages of the process.

Creators: director, actors, script writers

At the pre-production and production stages, three roles are prominent: director, actors and scriptwriters. Students can share these roles, taking turns to perform each role, thus contributing to both the creative aspect and to the understanding of the TC that they are communicating. The term performance applies to individuals performing to others in the group as well as to the imagined audience for the video. In a similar way, a film actor performs to the director as well as the camera, and thus any student performs to other students too in the group.

Students may draw storyboards in groups, write different scenes of the script individually, edit the script, and suggest alternative directions and depictions.

Scriptwriters

The scriptwriter's creative role is prominent at pre-production. The scriptwriter may also be the director, and a director may work with several scriptwriters. In a participative activity, the scriptwriter could be an individual or a group of actors, directors and writers who negotiate what certain lines mean and how they should be delivered. Thus, writing participative video scripts is a very collaborative form of writing. For JuxtaLearn, a video script specifies the video activities and interactions between performers and assets and, because the students write the script, they have to reflect on the activities they are going to perform, such as a titration. (Note that a video script is not the same as a computer supported collaborative learning script.) In fact, since the first stage of scriptwriting requires research (Kindem and Musburger, 2001) for correct facts and for inspiration, script writing encourages students to check their knowledge of the threshold concept. Hence, the script becomes a springboard for learning as well as for creative performance.

Directors

A director has responsibility for telling the story, for supervising, for working with the writer, and for shooting the film. The director considers how to depict the whole performance in terms of engaging with the genre, and displaying that genre through the given medium. Hence a stage performance of 'The Woman in Black', a mystery, will be depicted in a different manner from the film of 'The Woman in Black', yet still be within the same mystery genre. Therefore, you have levels of medium and of genre. The combination of unexpected genre and material and medium can create comedy. An example is an actor's change of hat to represent a change of character in "The 39 Steps" using only four actors to represent over 120 characters, a story the book of which was written as a thriller, but is acted as a comedy. The director chooses objects that induce ideas in the audience's mind, whether these be threats of revenge (e.g. the horse's head in *The Godfather*) or memories of childhood and innocence (e.g. the rosebud sled in *Citizen Kane*) (Harris, 2013b). In the JuxtaLearn process, the group can select from a performance palette of options. See D3.1.

In a film, the actors play for the director, thus the director is also the audience, and has responsibility for feeding back after each take (Rea and Irving, 2010). If each student takes on the role in turn, then the group has to collaborate to ensure that a coherent story is told. Students can check their story at the editing stage, and retake scenes to ensure cohesion and correctness. See also deliverables from work package 4 on editing. In video making, this is an iterative process: perform and take, edit, perform and retake. The teacher being present can observe if students have grasped aspects of the threshold concept being studied and can advise on the correctness of the story, thus encouraging retakes that better depict the concept. Therefore, the JuxtaLearn process combines group reflection combines with the expert's commentary.

Actors

Actors perform at the production stage, though are also involved earlier for example when reading the script. When performing, actors interact, using social techniques to a shared understanding. This allows them to create shared mental models. Fuller and Magerko (2011) discuss shared mental models and cognitive convergence in performers in improvisational theatre, identifying causes of cognitive divergences that include errors of commission, errors of omission, and sensory misinterpretation.

Performance techniques vary. Some performers will act, or present or do a voice over. Hence, a puppet master will use different performance techniques from those that a stage actor uses. Actors change levels of performance for example between rehearsed performances and improvisation. Orchestration of collaborative real time problem solving uses improvisation (Magerko et al., 2009). Improvisational theatre provides an example of creative, real-time,

collaborative problem solving (Fuller and Magerko, 2011). Creative approaches to problem solving have long been known to support understanding of counter-intuitive issues and can avoid mimicry (Maier, 1970).

One creative approach is ‘improv’, which is a theatrical genre, from improvisation that can be viewed as group real-time problem solving (Magerko et al., 2009). In improv, actors can use a variety of techniques to reach cognitive convergence. For example, they may ask for clarification, verification, present or demonstrate what they believe to be true. Alternatively, participants may quietly sit by, deferring comment until they understand through observation (Fuller and Magerko, 2011). Fuller et al’s (2011) work on improvisation helps to understand how students share their mental models, and improv might be a possible approach for acting STEM students to use in the perform step of the JuxtaLearn process.

Other roles

Other activities in creating a performance require roles such as stage manager, wiggies (those who specialise in hair and wigs), set designer, lighting crew, props assistant. In the JuxtaLearn context, such specialised roles are unlikely but could be shared between students depending on how large the group is.

Audience

At the post-production and distribution stage, students aim their JuxtaLearn performance at an audience of fellow students, peers and colleagues, the students' teachers and parents. In the JuxtaLearn process, the anticipated audiences grow with levels of dissemination. Initially, as students create their performance, their peers are the audience. Then their teacher becomes the audience as they edit, interpret and retake. Later, the audience becomes fellow students, people watching the large screen displays (LSD), and people who watch and discuss the video on the web.

An audience is an active not passive consumer (Hall, 1973). Audiences do not receive passively but actively respond and participate in creating the meaning of the performance (Chandler and Munday, 2011). Performances that create meanings that diverge between actor and audience will affect JuxtaLearn video audiences, who depending on the culture and context, may participate, review and comment on the performance. The audience requires a video that is worth watching, tells a story that the audience relates to. Performance is shared between actors and audience, and previous social experience and culture influence the way people interpret so an audience may or may not share the director's interpretation.

Although the students will use words to write a script, performance is not totally dependent on language. Indeed, for the JuxtaLearn process, performance when shared on LSD cannot use sound because of the expectation of ambient noise. Performance uses the visual dimension of set, props, resources, performers moving around – the visual and physical dimension is essential, and in the JuxtaLearn context technology mediates between creators and audience being a means to draw in the audience and engage people.

Participative video making

“Imagine a world where artists and technologists work together of their own accord ... focused on creating means of expression for others that can be shared” (Goodman, 2009)

Participative video making informs the JuxtaLearn process. Students collaboratively interpret, perform, edit & share their understanding of concepts through video, to reflect and learn. Participatory video, when a group of people produces a own video, involves a process in which participants can access video recording equipment and training to

ensure they can use the equipment to document the group's topic of interest (Jewitt, 2012). Jewitt (2012) categorises participative video in three ways:

- **video-as-a-product**, i.e. as an end in itself
- **video-as-production-process**, and the video making process may itself be videoed, e.g. for reflection or for research
- **video-as-editing-process**, i.e. a video can be edited to represent events in new ways

The second two ways are particularly relevant to JuxtaLearn. The video-as-production-process can bear more significance for all actors than the video-as-a-product because it allows reflection and generates knowledge (Blazek and Hraňová, 2012). Blazek and Hraňová's (2012) research explored layers of knowledge that young people produced through PV to represent their account of life in their local neighbourhood. Blazek and Hraňová argue that PV allows young people to create knowledge. Their experience was that other community members and policy-makers received the young people's video warmly. In the JuxtaLearn process, we do not yet know how the audiences might receive students' videos, or if student-produced videos can adequately convey the subtleties of knowledge production in STEM topics.

One theme that Blazek and Hraňová explored was the tension that PV raised between groups of young participants creating the video. A participative approach allows the students to demonstrate and develop their learning in groups, an iterative process (Corneil, 2012) that does not impart facts but requires "handing over agency" to the participants, starting thinking processes that challenge values and change people (Goldsmith, 2009). It is a tool to provoke and encourage reflection on behaviour (Wood and Olivier, 2011, Forsyth et al., 2009).

Group dynamics affect the potential for socio-cognitive conflict. Strong personalities may mean that quieter voices are stifled and leaders appropriate the whole video. In addition, the costs of collaborating mean less is produced (Ekeocha and Brennan, 2008). However, participative activity can also draw a student's attention to opposing viewpoints, as, working together, they become aware of discrepancies between their understandings of the TC. By encouraging group collaboration PV can provide a good medium in which to provoke conflict in order to facilitate learning (Jones, 1995). This has the advantage of encouraging iteration between performance and editing activities as students clarify their shared understanding, and as the teacher advises them. Negotiation and discussion are essential for reflection and learning. Through reflective listening students listen and restate in order to identify and clarify differences, and then reconcile them to accomplish task goals (White, 2003), iterating over the interpret, perform and edit steps of JuxtaLearn process. The steps are not sequential, but students iterate between them.

At the sharing and discussion stages of the JuxtaLearn process, social participation requires studying the given material on the TC, contributing, and collaborating. Preece and Schneiderman (2009) identify successive levels of social participation in an electronic discussion group: reader, contributor, collaborator and leader with fewer people moving from one level to the next, and moving in a non-linear way. Participation may be restricted to reading, or lurking, but trust encourages further participation as well as potential for personal benefit. Participants may restrict themselves to reading, or lurking, with few people moving from one level to the next, but people also moving in a non-linear way (Preece and Schneiderman, 2009). The parallel behaviour in the video making situation could mean that students at early stages study the material and contribute to discussions and storyboard, but hesitate to take an active and public role. That is, students personally produce knowledge but avoid sharing it publicly and risking social opprobrium.

Haw & Hadfield writing about video use in social science research identified purposes for using video. These included reflection, projection, participation and articulation (Haw and Hadfield, 2011).

- **Reflection** - video can support participants to reflect and to prompt reflection on what's been achieved
- **Projection & provocation** - video can support participants to examine and challenge what they think they know, to unpack problems and to kick start discussions
- **Participation** - Haw & Hadfield think about participation as a party metaphor in which the participation is the party and the video is the entertainment. In Haw & Hadfield's work, the host was the researcher who had the responsibility for bringing everything together, a form of orchestrating. In JuxtaLearn, we identify the host who orchestrates the participation, as the STEM teacher – see earlier section 2.1.
- **Articulation** - using video helps participants to voice opinions and communicate them to others. Haw & Hadfield think about articulation as a metaphor for a pop- song in which the project is the song and the participants the recording group. This may have resonance for JuxtaLearn in that a good JuxtaLearn video could be memorable and catchy, like a good pop song is. For Haw & Hadfield, the researcher was the producer of the pop-song. In JuxtaLearn, we suggest the students who produce the video take this role.

When the PV process embodies risks, then students need trust and support, the trust building process requiring sharing thoughts and feelings. Trust encourages further participation as well as potential for personal benefit (White, 2003).

2.3 Orchestration: performance environment

Location for performance

The expected JuxtaLearn pre-production and production location is the classroom, often light and airy but may be crowded, full of hard furniture, without soft furnishings to absorb sound. Cluttered walls display possibly out-of-date posters, and white boards perhaps have writing on, with spare extra wall space unlikely to be reachable. A science classroom with hard furniture, high stools, dirty sinks, will be bright and airy with two or three big science tables, a teacher's desk and work area, walls with jumbled display of science posters and admonitory warnings like 'wash your hands'. See Figure 2 - Science classroom. Where people are affects how they act and how they relate to each other.



Figure 2 - Science classroom

“the materiality of infrastructures, spaces and technological artefacts structure [...] knowledgeability.”
(Orlikowski, 2006: 465)

Materiality is the physical or virtual context in which people interact, including the material objects that they work with. Such material objects include shared physical tangibles, site and documents like storyboards and scripts, as well as mutually shared places (Orlikowski, 2007, Orlikowski, 2006), virtual or electronic environments, and intangibles such as time. Knowledgeability is the ability to acquire and use knowledge by negotiating meaning through a continual contextual process. From this, we understand that where students are and what material objects they use affects how they know what they know.

Time in combination with space is crucial aspect of environment (Maaninen-Olsson and Müllern, 2009). Orlikowski suggests that knowing happens over time, “changing in form and function” (Orlikowski, 2006: 462). The JuxtaLearn orchestrator needs to match the activities of the process against the available time slots.

Post-production and distribution stages of the JuxtaLearn process take place outside the classroom, such as when viewing large screen displays. Interactive systems that display videos in public places might arouse the curiosity of passers-by and change their behaviour. Tieben et al (2011) describe a flight of stairs that sound like piano keys as you move up and down them, encouraging passers-by to try the stairs instead of taking the adjacent escalator (The Fun Theory, 2009), the theory being that curiosity and the potential for fun changes behaviour for the better. Alternatively, people rather than technology can attract the audience attention. Brignull et al (2004) studied a large multi-user interactive surface set in a school common room, finding that students appropriated the surfaces, and drew in other students to see and share their video clips. We discuss this technology in section 3.2.

Objects for performance

Objects that are shared and sharable across different key parties are boundary objects (BO) (Carlile, 2002, Bechky, 2003, Star and Griesemer, 1989) and can help solve problems in a context where diverse groups of people work, such as editors, performers, audience and writers. Boundary objects are important to how language emerges and how, when people do things together. They structure practices. These common objects form and work at the boundaries between groups through flexibility and shared structure – they are the stuff of action’ (Star, 2010, p. 602/3) (Star and Griesemer, 1989). Thus, boundary objects “inhabit” several intersecting social worlds and satisfy the information requirement of each of them (Bechky, 2003, Star and Griesemer, 1989). Boundary objects can be used across social worlds to convey technical and social information and to mobilize action (Henderson, 1991, Star and Griesemer, 1989). Objects and representations therefore coordinate by providing information; they also provide a form of shared reference point around which people interact and create shared meaning.

In production, people use assets. Video-making assets are single components such as an individual clip, shot, a piece of music, photograph, or a logo. A theatrical property (owned by the theatre) or prop is an object used in the performance to make a story or as part of a story. For example, in a theatrical production of "The 39 Steps" two actors use several different hats to give the message that they are acting as any one of fifty different persons depending on the hat being worn. Assets can function as boundary objects between the director, performers and the audience.

Materiality shapes the use of an object, in the way that a wax crayon allows a different depiction of something from pen and ink, or a mouse on a tablet, the social and material entangling. Take a performer who walks into video shot, sees a letter, reads it, tears it up and walks out of shot leaving only torn paper. An email because it is a different material would shape its use differently from a letter, and subsequent action would be different. The paper is the object of attention, and the action draws that attention, leaving the audience wondering what was in the letter to cause that action. The action arouses curiosity – the letter is the object shared between performer and audience, and the expectation is that subsequent action in the video will reveal more. On its own, the letter begs questions and

indicates how objects can act as a catalyst for developing a story. Such examples can be seen in Marilyn Monroe's white dress in Wilder's 1955 film "The Seven Year Itch," and Mrs Robinson's stockings in Nichols 1967 film "The Graduate" (Harris, 2013a).

Doolin and McLeod (2012) propose five implications of sociomateriality for how we understand boundary objects. First, boundary objects are figured dynamically depending on where they are. Secondly, they change with use. Thirdly, its usefulness arises from its entanglement, resulting from its affordances. Fourthly, a boundary object allows different performances between occasions, sites, practices, and people. Fifthly, "diverse assemblages" (Doolin and McLeod, 2012 p573) of boundary objects imply a multiplicity of boundary objects. That is, an object is not a single object working on its own but in a mix with other objects, contexts and practices, so its meaning and use vary.

The next section discusses knowledge and examines knowledge boundaries then identifies what objects help to cross these boundaries.

2.4 Orchestration: knowledge

In this section, we identify a number of boundary objects involved in the JuxtaLearn process, including the taxonomy and pedagogical palette from WP2, and examine the role of storyboards and scripts in video making to support collaborative problem solving.

Levina & Vaast (2005) identified two categories of boundary objects: designated and in-use. **Designated boundary objects** are produced in one field and can be passed to another but without relating them to the practices within that field (Levina and Vaast, 2005). Designated boundary objects do not always help people to make sense. **Boundary objects-in-use** arise informally when different parties are developing something that ends up being shared with others as a means of helping exchange knowledge (Levina and Vaast, 2005). Boundary objects-in-use are first, useful in more than one field and secondly, acquire a common identity; they are shared.

Important material objects integral to the video making process are storyboards and scripts. A storyboard is a set of drawings that are a representation of a film in sequence and can contain elements such as dialogue. At the pre-production stage, students collaborate to create a storyboard as a creative response to STEM subject threshold concepts. Having decided what the elements are, they create a script. A script is a written account of a film containing scenes, dialogue, location, actions and actors, a means to establish the way the director wants the film to go. Storyboards and scripts are potential boundary objects that allow knowledge transfer between students creating the film.

The JuxtaLearn process is about learning; learning involves transfer of knowledge, so we propose diverting for a moment to look at knowledge transfer. Communication across boundaries is difficult because of the problems of "knowledge in practice" (Carlile, 2002 p. 453), which is knowledge that is "localised, embedded and invested in practice". We will identify these boundaries in the JuxtaLearn process and suggest how we can support STEM knowledge transfer at these boundaries.

Knowledge transfers over three types of knowledge boundaries (Carlile, 2002): syntactic, semantic and pragmatic.

- A **syntactic boundary** is based on existence of a shared and sufficient syntax at a boundary.
- A **semantic boundary** recognizes that differences exist/emerge, so individuals have different interpretations of word/event

- A **pragmatic boundary** recognizes that "differences in knowledge are not always adequately specified as differences in degree /interpretation, but that knowledge is localized, embedded, and invested in practice."

At syntactic boundaries, knowledge is transferred; at semantic boundaries, knowledge is translated; and at pragmatic boundaries knowledge is transformed (Carlile, 2004).

A syntactic boundary transfer allows accurate communication – in JuxtaLearn, scientific terms relating to the TC allow students to discuss the concept. For example, studying moles, all students must agree on Avogadro's number, as opposed to referring to an "*avocado's* number." A semantic boundary is a step further than syntactic because of differences of interpretation. For instance, a student might describe molecular mass in a particular way and the teacher needs to correct the description so that it describes *exactly* (i.e. *well defined, clearly distinguishable*) what is meant. A pragmatic boundary relates the practical and the philosophical approach of pragmatism, aiming at problem solving, predicting and acting – thus dealing with the negative consequences that arise through difference and novelty.

Collaborations require that syntactic, semantic and pragmatic boundaries be crossed. Each of these types of boundary can be crossed with the help of a boundary object that provides means of stepping over knowledge thresholds. Here are some suggestions as to what objects arising in the JuxtaLearn process might help at each boundary: the syntactic boundary, the pedagogical palette, at the semantic boundary, storyboards, and the pragmatic boundary, scripts. See Table 1: BO roles and effects at boundaries – based on Carlile (2002, 2004).

Table 1: BO roles and effects at boundaries – based on Carlile (2002, 2004)

Type of boundary faced	Boundary object role	JuxtaLearn boundary objects	Boundary object influences on JuxtaLearn process
Syntactic boundary	Knowledge is transferred	<i>Pedagogical palette</i> of threshold concepts, and storyboard	Breaking down the threshold concept in order to develop the taxonomy influences the teacher's creation of the pedagogical palette. Students and teacher develop a shared language
Semantic boundary	Knowledge is translated	<i>Storyboard</i> and <i>script</i> work at the pre-production stage.	Students, whilst practising the shared language, create shared meanings
Pragmatic boundary	Knowledge is transformed	<i>Video script</i> , with teacher intervention to reduce conflict, guide students & draw their attention to TC. At production stage, the editing process works on the <i>unfinished video product</i> .	Students and teacher develop common interests and may create new interpretations.

To cross a syntactic boundary, the boundary object has to help students create a shared language. Given the pedagogical palette, students can develop a shared language that allows them to specify and share perspectives, representing their differing knowledge of the threshold concept. In addition, storyboards not only support the creative participative video approach but also the learning process. However having a shared language, does not mean all students will have the same understanding of the threshold concept.

To cross a semantic boundary, the boundary object has to help students create shared meanings so they acquire new knowledge. The storyboard that they create is a shared boundary object that requires them to negotiate meaning as they agree the cartoons or pictures that they draw on it, and the text that they include. At the semantic boundary storyboard enable different conversations (Franco, in press), not forcing common shared meaning. The boundary object has to be visual, accessible and interactive if it is going to be valuable in increasing students' understandings and help them learn. The students' creation of the storyboard helps them identify and argue out shared meanings, negotiating meaning until and if they eventually agree. A storyboard as the only communication tool in the process may not be enough to get over the semantic boundary, enabling students to translate knowledge. However, it may also be the process of conversation between the students and the teacher orchestrating to guide the students' awareness to relevant concepts. Here the JuxtaLearn process iterates back to the interpret step, reinterpreting the pedagogical palette. That might suffice to create shared means.

To cross a pragmatic boundary when certain shared meanings generate conflict and negotiation, requires transformation of knowledge, like getting to information, creating graphs and other models, or designing experiments, which JuxtaLearn students could video. A document known as a "video script" is a written account of a film containing scenes, dialogue, location, actions and actors (See glossary in D3.1). Written into a video script is who says a specific sentence to whom and when, as well as what objects (assets), the actors are currently wearing or holding in their hands. It plans the interaction to take place between the actors (the "how do they do that"). This script physically represents collaboration between students and is a kind of contract determining the allocation of effort and interpretation. Video scripting that supports collaboration allows students to allocate activities and handle resources, such as assets for filming.

We note that computer supported collaborative learning (CSCL) scripts are different to video scripts. A CSCL script has learning objectives with prescribed activities that structure the learning in a particular sequence. A video script establishes a way the performance should develop. Both types of script are flexible, the CSCL being flexible so that the teacher can adapt it to deal with contingencies (Dillenbourg and Tchounikine, 2007), and the video script can change as the director and actors interpret and reinterpret it. A video script need not stick to the sequence in which it is written, for example because the shoot of various scenes of a video can take place in a different order from that in which they are eventually shown. Thus, in a school context for example, if an early scene were required to take place outdoors but the current weather was inclement, students can nevertheless film later scenes such as a piece to camera (PTC) indoors. For an example of a video script, see appendix of D3.1. These are different scripts for different purposes; one plans creative production; the other plans activities for learning.

However, a boundary object can both constrain and afford interaction and transfer of knowledge causing problems at a pragmatic boundary, if, for example, a powerful student uses the object to constrain action and opportunities for the others. Franco (in press) indicates that good content is not enough to transform knowledge but that the object has to afford participant interaction; it has to be a boundary object-in-use (Levina and Vaast, 2005), which it can be only if it allows people to traverse all three knowledge boundaries. Boundary objects need to be tangible, associable (to allow creativity), mutable (to allow crossing of knowledge boundaries), traceable and analysable (to allow experimenting with knowing). Finally, a boundary object has to afford opportunities for interaction.

Interaction requires that meanings must be negotiated, so managing the boundaries of knowledge needs someone effective: the orchestration factor of teacher centrism guiding students, drawing their awareness to particular knowledge, because their discussion and creation of storyboards has drawn the teacher's awareness to their need for further guidance. Boundary objects that intermediate interaction cannot replace the JuxtaLearn process, which needs the teacher to orchestrate at the pragmatic knowledge boundaries, deciding when and whether to intervene; the teacher is essential to getting knowledge transformed at the pragmatic barrier.

The JuxtaLearn process requires boundary objects in-use; "plastic, reconfigurable (programmable) objects that each world can mould to its purpose" (Star and Griesemer, 1989 p404) such as the video script created through negotiation with others students; abstract or concrete objects like the pedagogical palette, storyboard and script. For instance, the pedagogical palette will be instantiated through storyboarding, the tabletop and other touchable interfaces and the editing process thus being concrete, tangible and visible. In addition, it will be used to scaffold not only the students' work as they create and edit their videos, but also to scaffold the teachers as they create their standard teaching activity exemplars (pencasts) thus being flexible.

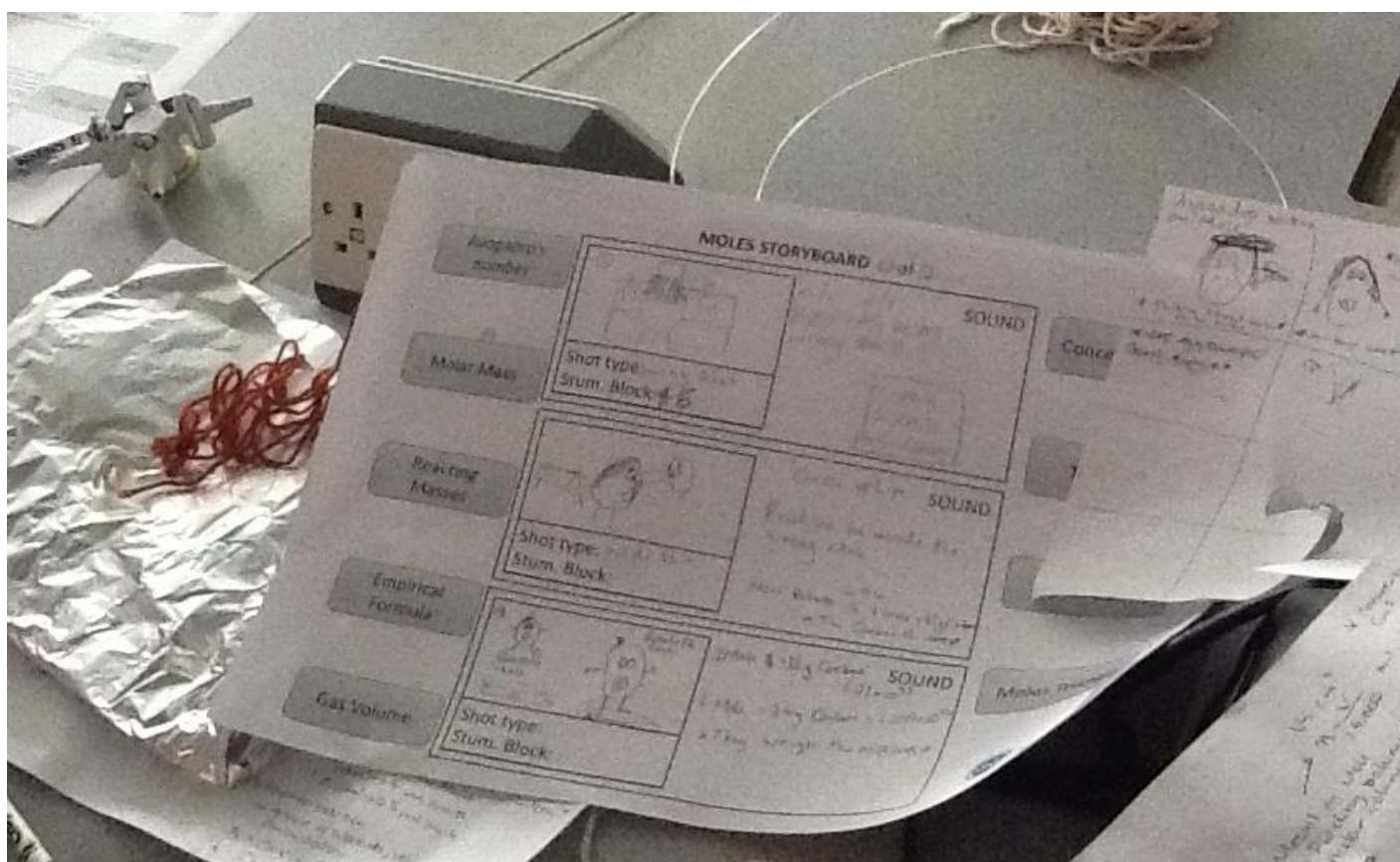


Figure 3 - Storyboard

Storyboards on paper - see Figure 3 - are concrete objects that make the PV process visible partly because moving paper physically around the classroom makes the students and teachers aware of who is sharing what with whom. They should be associable, i.e. related to shared attributes that cross the boundaries that allow creativity (Mednick, 1962).

The JuxtaLearn process provides opportunities for playful combinations by juxtaposing scientific ideas with creative skills. First, creativity might be considered the ability to innovate or to arrive at a good idea when you need one (Claxton, 2011). Secondly, creativity requires "the formation of associative elements into new patterns that either meet specified requirements or are useful" (Hutton and Sundar, 2010: p294 citing Mednick, 1962). Thirdly, the process of creativity involves interpreting associations: Mednick (1962) defines the creative process as "the forming of associative elements into useful new combinations" (p221) and a creative answer as both useful within given requirements and original. He identifies three ways to achieve creative solutions: serendipity, similarity and mediation.

1. **Serendipitous** solutions arise through accidental environmental contiguity.
2. **Similarity** evokes solutions through eliciting associations. Similarity may be important in areas where symbols do not count for much such as painting and poetry.
3. **Mediation** is when associated elements become contiguous through symbols such as in maths or chemistry

Fourthly, the more familiar particular associations are, the less likely you are to find creative solutions. Conversely, the more associations evoked, the more likely it is that an individual will find a creative solution because some associate will mediate as a bridge to facilitate combinations.

By associating reflection on STEM subjects with performance through video making creation, the JuxtaLearn process should provide an incentive, a process and an environment to create unlikely combinations and good ideas that lead students to new insights. For example, students might relate STEM concepts to everyday situations (like chemistry in cooking, or the physics of traffic or of the body in a martial art, or maths in dancing).

The JuxtaLearn process requires students to explain a difficult concept and to create a film or video of it, a process that entails

- understanding a threshold concept, and
- being able to explain the TC - a different skill.
- representing this complex abstract topic in a different medium
- performing and explaining together, i.e. collaboratively – another skill. Working together may mean one student can arrive at a good idea for the performance while other students can explain the concept. Working together also requires shared mental models (Magerko et al., 2009)).

It is a mentally and socially demanding activity, of understanding a complex abstract topic and then re-presenting it in a new medium. If it is hard to see how opportunities for 'playful combinations' arise, it may be because we assume that these two socio-cognitive activities conflict and should be reconciled. However, these activities are not for reconciling, but for juxtaposing: playful combinations should arise through the process that juxtaposes science learning with creative explaining.

3 JuxtaLearn framework for systems to support STEM subjects

The JuxtaLearn process requires a framework to scaffold orchestration of participants, environment and knowledge. JuxtaLearn requires participants with knowledge to acquire and share, space to play, perform and create videos, space and equipment to edit, and to display, time to play and reflect and learn, and a means of storing video data and searching for video clips. Dillenbourg and Jermann (2010) describe several factors related to designing a learning environment: teacher centrism (leadership, flexibility and control); cross plane integration, sequentiality

(linearity, continuity and drama); time management (relevance and flexibility again) and physicality, which includes awareness. The following Table 2 indicates how the orchestration factors support participants, environment and knowledge. See also D3.1.

Table 2: Framework for JuxtaLearn performances

Orchestration factors (Dillenbourg and Jermann, 2010)	Comments on JuxtaLearn orchestration	Participants, environment, knowledge
Teacher- centrism (leadership, flexibility and control)	Integrating people and physical assets requires combining dimensions of timing and interplay of activities. Conventional teaching activities juxtapose with alternative video creating activities.	Participants
Cross-plane integration	STEM concepts integrate with learning and practicing use of video technology.	Participants, knowledge
Sequentiality (linearity, continuity and drama)	At the macro-level of orchestration, the overall process is sequential. The JuxtaLearn process has eight steps that although iterated between, overall aim towards the final step. The next section will show the sequence of the steps. However, at the micro level, in video making, shooting performances can occur out of the sequence that they will be shown in the final product.	Environment
Time management (relevance and flexibility again)	The teacher needs to draw students' attention to time management, and to explain constraints on timetables such as it not being possible to devote two consecutive days to learning a concept and videoing for it.	Environment
Physicality, which includes awareness	The teacher guides attention through using physical materials and space.	Environment, participants
Flexibility	Guidance is required from the teacher to plan, to abort and change plans, and to guide separate groups working in the same space, so they do not hamper each other.	Participants, flexibility of time & space (environment)

When an educational context frames the performance, only the teacher sees the product, and the process is often a solitary student activity done alongside but not with other students. The JuxtaLearn process of performance goes further than normal classroom orchestration in requiring that students collaborate through creating videos of STEM subjects. A framework helps interpret and understand what students have achieved, particularly if it allows and encourages them to compare their performance with other students' performance on similar topics. For students to understand how their audience perceives their work, it is essential they reflect (Leijen et al., 2012).

The following section scaffolds the JuxtaLearn environment for its participants and a later section looks at knowledge in the context of storing and retrieving it as recorded video data.

3.1 JuxtaLearn framework: classroom and performance environment

Scaffolds are rarely independent structures, but require something solid to provide stability, and in the classroom, the teacher provides the stability. The teacher provides STEM knowledge and is central to the orchestration of the JuxtaLearn process. The addition of a drama teacher who provides knowledge of performing techniques could brace the teaching scaffold, but is not expected as part of the JuxtaLearn process.

Preproduction stage

The preproduction stage covers the first four steps of the JuxtaLearn process: identify, demonstrate, interpret, and perform.

Stages	Objects	Space	Time
Identify	Pedagogical palette of threshold concepts	Class room, science labs	Class periods of an hour or an hour and a half at a time, spread over days not weeks
Demonstrate	As well as technology objects, material objects to share are pedagogical palette of threshold concepts, storyboard, and script.	Classrooms, science labs, corridors, fields, playground, hall, and web People in the space – audiences	
Interpret	These objects help creation of the video and, by crossing knowledge boundaries, allow negotiation of meaning and shared understanding.	Class room, science labs	Interpreting requires discussion, reflection and research, including asking the teacher to elaborate, explain and confirm.. Performance planning takes time, not necessarily a full day, but often longer than a lesson session. If a storyboard plans to use particular props, then students need a break to obtain them.
Perform	For creativity, we require a performance palette that allows different genres and performance techniques, including mime, improvisation, and music. Other genres: piece-to-camera, on-visually human such as puppets, or animation, and non-textual such	Classrooms, corridors, fields, playground, hall, and web	

Stages	Objects	Space	Time
	<p>as juggling, magic, can all be used to explain a theory, sometimes more powerfully than the word alone.</p> <p>The JuxtaLearn process involves much technology: data pens, phones, cameras, table top computers, and public displays.</p>		

Production stage

The production stage covers the fourth and fifth steps of the JuxtaLearn process: perform and edit. The edit stage might be considered postproduction, but for the JuxtaLearn process counts as both production and postproduction because editing encourages discussion, reflection and learning as the participants agree which takes to keep and which to delete.

Stages	Objects	Space	Time
Perform	Students need to plan text to explain the TC. Deciding what text and where to place it encourages reflection and reinforces learning, so is likely to highlight misunderstanding, and where students have missed the point or misinterpreted concepts.	The performance space is not going to be the same as the sharing space, but students need to remember that some sharing spaces will prevent or reduce sound. The large screen displays are likely to be in noisy spaces, where interaction could be difficult, uncomfortable or embarrassing.	This is going to be class time and probably daytime, so creating dark or night-time scenes may require creativity, technical knowledge or out-of-hours effort.
Edit	Because the environment for large screen displays precludes sound, editing needs to incorporate other clues than voiceover or narration. Text over for key bits, and descriptions of what is happening with text annotations for key elements perhaps using different and smaller font, draws your attention to the text so that	Where sound is important, edit to create two versions: one for the web with sound and one for large screen displays. See also deliverables from WP7 system integration.	Allowing for time has to be an elastic factor because some ideas are simple, but others, craftier, take longer to realise and implement.

Stages	Objects	Space	Time
	the viewer still gets the story.		

Postproduction stage

The postproduction stage covers the last steps of the JuxtaLearn process: edit, share, discuss, and review

The JuxtaLearn process requires making time at post-production (sequentiality) for sharing the students' films. The "screening" (See D3.1 glossary) is a special first showing to a film's participants and their teachers, fellow students and parents. In the JuxtaLearn context, such performances are anticipated to go before wider and potentially unknown audiences on the web in many European countries. Therefore, this special screening allows the students to share and validate their work with a trusted audience.

JuxtaLearn performers do not directly engage with their wider audience because the technology sets the performers apart. However, the screening allows for that first interaction; if the audience at the first screening react in a way that the performers did not expect or want, then the teacher might consider withdrawing the video. The process must include that first screening event with the creators' supporters present, because if the supporters react badly, there has to be that opportunity NOT to put the video up for further dissemination until it has been edited and redone. After that, the bulk of the postproduction stage will be through public display on large screens, and in web spaces, which the next two sections will address.

Tieben et al (2011) designed an interactive system to arouse curiosity and influence behaviour in a playful way. They identify and define from the literature five main principles for evoking curiosity: novelty, partial exposure, complexity, uncertainty, and conflict. They suggest the curiosity process is circular: encounter something novel, explore, discover, and adjust. They then tested their theory by setting up interaction scenarios to attract passing students, using sounds as a medium to elicit curiosity. They created varying sounds, and observed students action from discrete web-cameras. As a result, they found that, novelty drew initial attention, but that novelty wore off. Partially exposed information drew the eye but did not halt the students; the passer-by must be interested in the information. Variable and ambiguous sounds elicited a lot of curiosity, especially as passers-by were rewarded by discovering more information. However, there is a distinction to be made between "eliciting curiosity" and provoking learning. Ambiguous sounds may capture attention, without necessarily leading to further interest and exploration. In JuxtaLearn, sound is not always an option because of conflicting noise when videos are publicly displayed.

Overall, an interactive system could elicit curiosity and the next section will explore such systems. Other factors that influence its evocation are user traits, openness and expectation, the environment (physical & social), and memory; a school corridor is different from a shopping centre. The materiality influences action and learning.

3.2 Audience behaviour frameworks for engaging with public displays

JuxtaLearn aims to explore the shared nature of public displays as an additional vehicle for driving engagement, curiosity and visibility around JuxtaLearn videos. Extending performances to the situated displays raises the need for managing audiences and model engagement. Interaction with public displays is mostly expected to occur as part of a public setting where many people may be present, typically carrying out multiple activities and having their own goals and context. Therefore, for interaction to occur, the display must be able to attract and manage people's attention. An important step towards sustained engagement with public displays is thus to make the flow of people

around the display a key part of the interaction design process. A number of audience behaviour frameworks have been proposed (Streitz et al., 2003, Vogel and Balakrishnan, 2004, Brignull et al., 2004, Dix and Sas, 2008, Dix et al., 2008, Michelis and Muller, 2011) to represent the various phases of engagement with public displays and the transitions that occur between those phases. They describe the interaction process as a series of different phases, usually sequential, that users need to go through to move from being simple passers-by to being engaged users. Understanding this process is fundamental for conceptualising the interaction flow around public displays and should also become part of the JuxtaLearn performance framework.

To incorporate the need to connect the audience with assessment of and engagement with the video, the next two models provide bases for quality indicators, assuming that the conversion-rate from passer-by to participant is an indicator for the performance quality of the video.

Dix and Sas

Dix and Sas propose an audience behaviour framework inspired by urban artistic performances, such as street theatre, that include members of the public (Dix et al., 2008, Dix and Sas, 2008). They exclude the performer role and divide people into two categories: participants (members of the public who in some way affect the performance) and bystanders (general public not 'part of' the performance). These categories are also divided into whether they are 'witting' or 'unwitting' depending on the awareness of people. The result is the following list of five possible roles:

- **passer-by** – may know screen is there, but does not watch or interact with it
- **unwitting bystander** – sees the screen but does not realise interaction is occurring. This is someone who may simply be doing something else near the screen but who is not aware of what is going on regarding interaction with the screen.
- **witting bystander** – sees the screen and realises interaction is occurring. This is someone who may be seen as the passive audience of whatever is happening
- **unwitting participant** – triggers sensors to have some effect, but does not know it. This is someone that is sensed by the system, is filmed or in some other way is part of the performance but just does not realise it.
- **participant** – actively engaged with the system doing some form of input/interaction. This is a person that is actively involved in the interaction.

Going from being a simple passer-by, who may not even know the screen is there, to being an active participant interacting with content, is a multi-stage process that involves multiple transitions as described in Dix and Sas (2010) and represented in Figure 4.

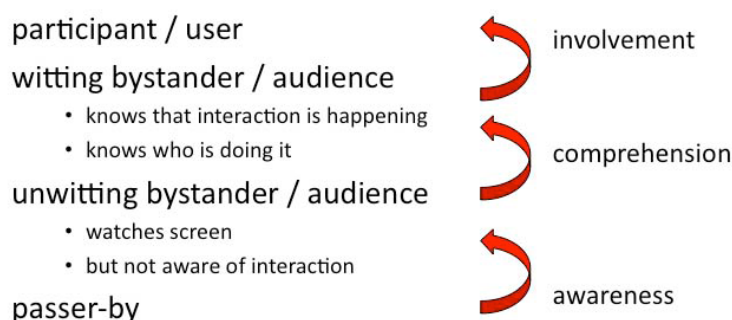


Figure 4 - Changing roles in public screen interaction

Awareness: First, the passer-by has to notice the screen. For the large city-centre screens, this is not really an issue, but for smaller displays, in a world where displays everywhere are the norm, drawing attention to a particular interactive display may be less easy.

Comprehension: Having noticed the display the unwitting bystander may not realize that the display is interactive and think it is just broadcast information. Furthermore, even if they realise it is interactive, they may not know how to interact with it. Some fresh understanding is needed for the display and its interaction to become comprehensible.

Involvement: Finally, the witting bystander needs to find the display compelling enough to choose to interact and become an active participant.

Audience Funnel Framework

Michelis and Müller describe the Audience Funnel (Michelis and Muller, 2011) as a framework that focuses on observable audience behaviour. This framework is derived on observations from the Magical Mirrors installation, which consists of four displays showing a mirror image of the environment in front of them, overlaid with optical effects that react to the gestures of the audience as recognised by a simple motion detection system based on a single camera. As part of their observations, they identified a number of typical processes: *“Passers-by first glanced at the displays and then moved their arms to cause some reaction of the displays. Then they positioned themselves in the centre of the displays to explore the effects. Finally, they approached the other displays and in some cases took photos of the displays and posted them on the web”*. From these common processes they identified six phases, as represented in Figure 5 (Michelis and Muller, 2011).

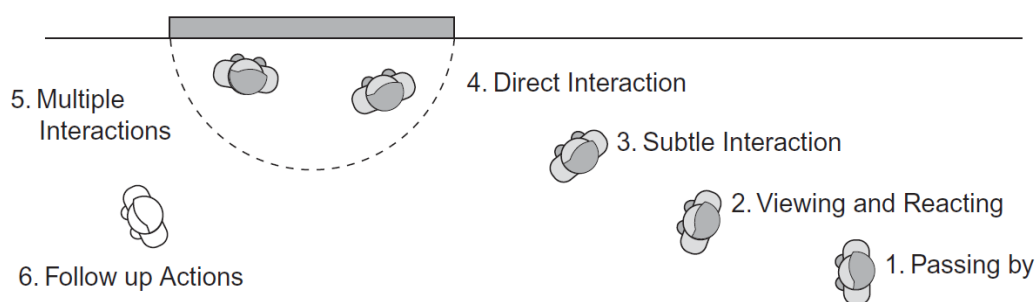


Figure 5 – Engagement phases in the Audience Funnel framework

These phases are described in Michelis and Muller (Michelis and Muller, 2011) as follows:

Passing By: Everyone who happens to be present in a certain vicinity of a public display can be called a passer-by. The specific area depends on the concrete instance of the public display, in principle involving anyone who could see the display. For operationalization, this area usually must be restricted to just the people sufficiently close to the displays that they can be observed in practice. In the case of Magical Mirrors, this was operationalized this variable as the number of people who entered a 4 m radius of the displays (effectively, everybody who was passing the displays at the same side of the street).

Viewing & Reacting: As soon as a passer-by shows any observable reaction to the displays, such as looking at it, smiling, or turning his head, he can be considered a viewer. The mere fact of somebody quickly glancing at a public

display can be very difficult to observe manually. Future eye-tracking technology or camera-based eye contact sensors might make this observation feasible, and some audience reactions, like craning the head or smiling while passing by, might be easily observable.

Subtle Interaction: As soon as the viewer shows any signs of movement that is intended to cause some reaction by the display, we can call him a subtle user. In the case of Magical Mirrors, this often coincided with briefly pausing in front of the display or by moving toward the screen. Subtle interaction occurs at several meters distance from the display, where the person engaged in the interaction does not occupy any part of the display for herself and allows for the simultaneous interaction of others. This variable was operationalized to include all viewers who appeared to do some movements with the intention of seeing the reaction of the display. Although this operationalization may seem difficult to observe, in practice such actions proved to be obvious.

Direct Interaction: After some initial subtle interactions, users usually tried to position themselves in the centre of the display. This is a very distinct feature for Magical Mirrors that allows us to distinguish between subtle interaction and direct interaction. Such a user can be called a direct user. In the case of Magical Mirrors, this coincided with the user entering a relatively small area of about 1 m around the displays. When positioned centrally in front of the display, the user blocks the view of the display from others. A person interacts directly when she actively engages the display for some time and positions herself centrally in front of the displays.

Multiple Interaction: Many users started to interact with the other displays after a phase of direct interaction with one display. Such a user can be called a multiple user. In addition, whenever a person consciously stops the direct interaction, but then returns to reengage the display, this is also considered multiple interactions. We operationalized this variable as any user entering direct interaction with at least one other display (or the same) after having interacted with one display.

Follow-Up Action: As described, many users conducted follow-up actions after direct or multiple interactions. For example, they took photos of themselves or their friends while interacting with the displays and uploaded these to the web. It consists of different subsequent phases for each of which a conversion rate can be calculated as the user moves to another phase.

An interesting property of the Audience Funnel framework is the focus on observable behaviours that can be quantified to generate conversion rates between the different phases. At each transition between phases, only a certain percentage of the audience can be retained, as exemplified in Figure 6 (Michelis and Muller, 2011).

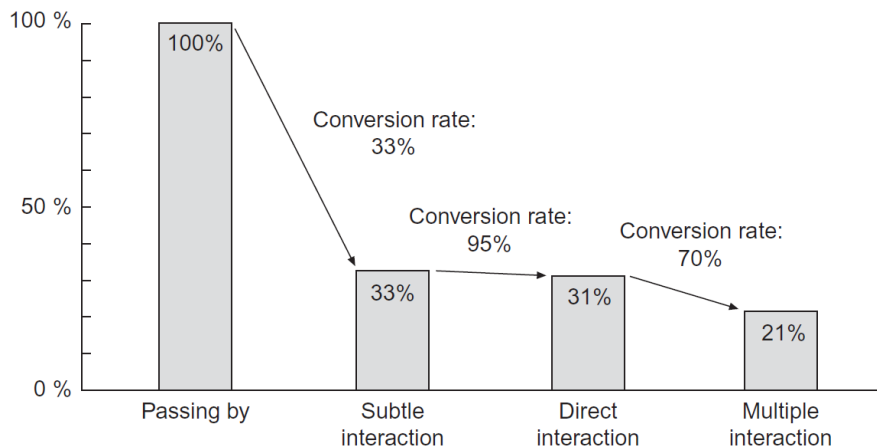


Figure 6 - Conversion rates between phases

This explicit identification of the conversion rates provide a valuable tool for identifying where the main engagement barriers may exist and drive interaction design to address those obstacles. This model could be another basis for an performance indicator of a video. Like above the conversion rate between the different phases could be an interesting measure.

Analysis

Designing for interaction is about maximising participations and the number of people that cross the interaction phases. For JuxtaLearn performances, this means that videos and their presentation on public displays should clearly entice people to interact with the content. This may be achieved through quizzes that entice people to go beyond mere observers by engaging in some way with the content. It may also include mechanisms for allowing people to bookmark videos considered interesting and possibly to drive people to further exploration at the web space. The work that will be conducted on interaction with the public displays (to be reported in D5.2) will clarify the design space for these forms of engagement through the public displays. For further analysis, see WP5 deliverables.

3.3 Web space

This section discusses web space, sharing and organising, storing and retrieving them, performance indicators from the web space and finally it considers ethical use of the web space.

From the point of view of social psychology, cooperation and collaboration contain many advantages for the individuals, but also for groups. For example, the collaboration in a group may achieve a result that could not be achieved by any of the individuals forming the group (Stahl, 2006). Furthermore, (Harrer, 2000) assumed that the knowledge of a heterogeneous group may be bigger than the knowledge of each individual and therefore leads to better results. Additionally, (Reimer, 2001) found that errors can be better detected and avoided in a group, as the interaction inside of the group supports the generation of insights and ideas (Harrer, 2000). As (Stahl, 2006) explains, these advantages are not restricted to face-to-face situations, but also found in technology supported learning environments as well.

Newer results from media psychology on the motives of media usage and participation in social media platforms indicate that the “Uses-and-Gratification approach” (Katz et al., 1974) may be applied to explain human behaviour

with respect to online platforms. The “Uses-and-Gratification approach” (Katz et al., 1974) explains why people use media and what they consider rewarding enough to repeat their usage. Döring (2004) shows that this approach combined with other motives is applicable to internet usage as well. According to Haas, Trump, Gerhards et al (2007) entertainment especially requires information and communication.

Therefore, it is important that besides simple usage, which is an inevitable pre-requisite for long-term usage, it is important to take into account these motives while planning a learning platform to be able to satisfy these motives (Sträfling et al., 2011).

Of course, the provision of relevant information (e.g. task descriptions, the pedagogical palette etc.) is mandatory, but also the need to communicate and to be entertained should be considered. These needs may be satisfied in the JuxtaLearn case by providing means for communication (e.g. forums, comments) and edutainment (e.g. videos, quizzes). Forums and comments may be used to communicate and thereby make affiliation with other people. Thus, these tools may satisfy the “need to belong” (Baumeister and Leary, 1995). Furthermore, such communication tools enable an interaction between learners without the restriction to a co-located group. This allows for interaction between learners which may lead to a beneficial exchange between them (Cross, 2003, Stahl, 2006) supporting peer-helping and peer-learning (Topping, 2005); (Boud et al., 1999). Among other tools, Kimmerle, Moskaliuk, & Cress (2009) consider the following tools helpful for the communication between learners and with approved impact on learning (Kimmerle et al., 2009):

- Blogs
- Folksonomies (tagged contents)
- Podcasts (with or without video)
- File sharing, document sharing

Krämer & Winter (2008) argue that another important aspect for the success of a media platform is the potential to present oneself, because this enables the users to compare themselves to other users. Comparing oneself with others is another master motive for explaining human behaviour (Festinger, 1954). This motive may lead to participation either to present success stories (like videos) or insights or to compare one’s own performance with others. In this context, reputation (e.g. represented and/or earned by likes or five-star ratings) are often used.

Besides the motivational issues, the platform has to support the teachers in their pedagogical processes. At least basic monitoring facilities have to be provided to support the teachers as moderators. Examples for basic monitor and or moderation tools are visualizations of the cooperative processes (e.g., collabograms, activity meters (Jermann et al., 2001)). Furthermore, the platform should support the underlying pedagogical or instructional process and the tools should guide the students in their process. One example may be sentence openers or prompts, which help to structure comments on videos or the visualization of the pedagogical palette scaffolding their video creation task.

Looking at the trial conducted within WP6 (D6.1) with students from a university course at URJC, the requirements derived from theory are supported by their feedback as:

- They found the private group discussion tools useful [“need to communicate”].
- They liked the five-star rating tool [“need to compare”].
- The students asked for clear criteria to rate and to comment the videos (ex. a video rubric) [“need for scaffolds”].

- Although the students did not use bookmarks, tags and photos, they considered that these tools could be useful in the future [“document sharing”].
- The students did not think that micro blogging, chat, and the “Like” option (similar to Facebook are useful to them [was not mentioned in the instruction; was not supporting the current instructional process].

Especially the last observation that the students do not value tools that are not immediately part of the learning process or which seem to be duplicates of other (more expressive) options (likes vs. five stars) shows that it would be good to be able to adapt the web space system to group specific pedagogical needs - in the sense of orchestrating the learning process – by the teacher. This can be achieved for example, by being able to turn off and on some of the tools provided by the web space system depending on the current group and learning process. For further analysis, see WP6 deliverables.

Sharing and organizing videos

Apart from the pedagogical and psychological considerations the platform will also need to fulfill the basic JuxtaLearn process requirements by providing facilities for video sharing within a group of learners, within institutions via public displays and hopefully also between different groups of learners at different institutions. At the moment, the web space (D6.1) can be used as a central repository for storing the intermediary results of the different stages, storing videos locally, albeit it allows for external videos to be embedded via URL pasting. Indeed, the platform's “Group” module allows contents to be shared group-wide only, and only the finished product will be published as public (site-wide).

Videos linked by URL will also be displayed on line with an embedded video player. Videos can be shared in two different ways: inside groups and public for the entire classroom. On the one hand, students in the same work group can share any type of material to create the videos (e.g. different versions of the video). On the other hand, when the video is ready to share publically, students can share with the rest of their classmates. Thus, they have an internal space to work in the video creation process and the public classroom space for sharing with all the classmates.

In the current version of the web space, both teachers and administrators are in charge of moderating all user contents to ensure that comments that could offend or upset the young people are blocked or removed. Teachers have administrator rights and can moderate comments and remove inappropriate contents or comments.

Over time, there will be many videos produced by different groups of students. Thus, there is also a need for structuring the content. One way of doing so, is the usage of tags. They can be used as index terms in a search and they should be derived from the Taxonomy terms (see D2.1) as the taxonomy seems to be a structure already known by the students and inherently task related. For example, to show students existing JuxtaLearn videos about moles, enter 'moles' as a tag and expect to see a list of relevant videos.

As well as web space for sharing performances, the JuxtaLearn process requires managing the data that is in the web space and that is elsewhere, which will be discussed in the next section.

Storage & retrieval

Educational establishments will need to pay attention to how much space video data takes up, considering how to store video data files, in what format and where, in order to allow secure access for searching and retrieval. The next sections look at the JuxtaLearn requirement for video data storage and retrieval, and the ethics to consider when managing JuxtaLearn video data. Deliverable D6.1 describes the web space for sharing. The process starts off-line,

and the on-line sharing is step 6 of the JuxtaLearn process, so JuxtaLearn needs a framework for storing and managing the initial data at steps 4 and 5 (performing and editing).

"The durable, malleable, and shareable character of video data raises challenges for the researcher related to storage and ethics" (Jewitt, 2012 p8)

Each educational establishment that produces JuxtaLearn videos faces challenging in deciding who has responsibility for data management, and will need to develop a data management and sharing plan so that they can use and protect their data long term. The plan should:

- guarantee the encryption of the data (if required)
- facilitate sharing so that people can access it on multiple workstations
- Distribution needs to be transparent, so video management requires storage and software that allows distribution, adaptation, and collaboration between the JuxtaLearn institutions, noting that it is difficult for collaborating institutions to get access to a shared place that holds so much data. See Table 3.

Table 3: Ways to share data, from Van den Eynden (2011)

Means to share data	Advantages	Disadvantages
Deposit them with a specialist data centre, data archive or data bank Consider using YouTube or Vimeo, which allows private sharing.	<ul style="list-style-type: none"> • assurance that data meet set quality standards • long-term preservation of data in standardised accessible data formats, converting formats when needed due to software upgrades or changes • safe-keeping of data in a secure environment with the ability to control access where required • regular data back-ups • online resource discovery of data through data catalogues • access to data in popular formats • licensing arrangements to acknowledge data rights • standardised citation mechanism to acknowledge data ownership • promotion of data to many users • monitoring of the secondary usage of data • management of access to data and user queries on behalf of the data owner 	Data centres may not be able to accept all data submitted to them
Deposit them in an	The educational establishment has ownership so	Institutional repositories may not be able

Means to share data	Advantages	Disadvantages
institutional repository	can manage the original data for privacy and access. This might be appropriate for video data in its early stages: perform, edit.	to afford long-term maintenance of data or support for more complex research data
Make them available online via a project or institutional website	This is the JuxtaLearn web space, described in D6.1 and specifically designed to share JuxtaLearn videos. This is essential for the later stages in the JuxtaLearn process: share, discuss.	Many websites are ephemeral with little sustainability, but the JuxtaLearn web space is planned for the life of the JuxtaLearn process.
Make them available informally between establishments on a peer-to-peer basis	Informal access	Note that it is difficult for collaborating institutions to get access to a shared place that holds as much data as video storage requires. Using attachments is expensive on email space.

Storage requirements are huge and because there will be so much data, searching will require metadata, tags and labels (Derry et al., 2010), and these could be elicited through the web site as videos are uploaded.

At post-production stage, it is advisable to create different versions of the videos; one in full size, and another converted into smaller files with fewer details. Larger files can be backed up on to DVD or removable hard drive. Smaller files, being more portable can be more easily shared, and may be stored in the cloud (Dropbox, Box, iCloud, SkyDrive) in encrypted form. Options for cloud storage include DropBox, SpiderOak, Microsoft's SkyDrive, Box, GDrive. Folders, files, and file names need standardising too for easier retrieval. Each educational institution group is likely to have its own standards already, but if videos are to be more widely shared and retrieved then a wider discussion of standards is needed.

Finally, a time will come when the data is no longer required, and some institutions might want to destroy their own data. Alternatively, continued controlled and restricted access might be sufficient. Again further discussion between JuxtaLearn educational institutions is needed.

Deliverable D3.3 will analyse and compare storage options, and then recommend one as part of the specification for JuxtaLearn. The whole team, all the partners, will need to agree on an option, one that all the JuxtaLearn educational institutions can share.

Performance indicators from artefacts generated inside the webspace

The students' performance takes place in the form of creative video making and editing activities. In the videos, students may appear as actors, or they may use avatars, puppets or other (virtual) artefacts. Video production is followed by sharing the videos on a learning platform with annotation and discussion facilities. The production of videos on scientific subjects on the part of the students is a variant of "learning by teaching" that could be labelled "learning by performing and presenting". An issue that needs to be considered is that the production of videos

should stimulate and foster the acquisition and consolidation of scientific domain knowledge instead of focusing attention and efforts on the secondary task of creating “nice” videos. Therefore, we want to identify indicators that enable us to support the learners to stay focussed on the learning process, and the teachers to intervene if necessary. To gather first experience and empirical evidence, an experiment has been conducted with an experimental group of computer science students (Daems et al., 2013). In this experiment, the interdependence of three aspects of video sharing in a learning community: social interaction, assessment (rating) of videos and the semantic richness of annotations in terms of domain concepts has been investigated.

The JuxtaLearn web space (D6.1) enables users to join groups and post videos as a group instead of as an individual. Users can post comments and assign “likes” and ratings to a video individually. As shown in Figure 7, the data structure of JuxtaLearn’s video platform allows ascribing several attributes to videos and users. On the one hand, the five star rating assigns a quality rating to a video per user basis resulting in an average quality rating for each video (\emptyset Quality). On the other hand, the average value of all five star ratings assigned by a user to respective videos characterizes the user. Since comments are attributed to a video and are written by a user, it is possible to assign average semantic richness and sentiment values (\emptyset semantic richness, \emptyset sentiment) to a particular video based on the average of the corresponding values of all comments on this video. Semantic richness is a measure for the technical vocabulary from video’s sciences field used in a comment. Sentiment describes the general attitude of a comment, i.e. if it contains more positive (e.g. praising) or more negative, (e.g. criticizing) connoted words.

As with the five star rating, we can attribute the users with an average of their comments’ semantic richness and sentiment. Of course, it is also possible to attribute basic numbers like the amount of comments (# comments) or ‘likes’ (# likes) to every video.

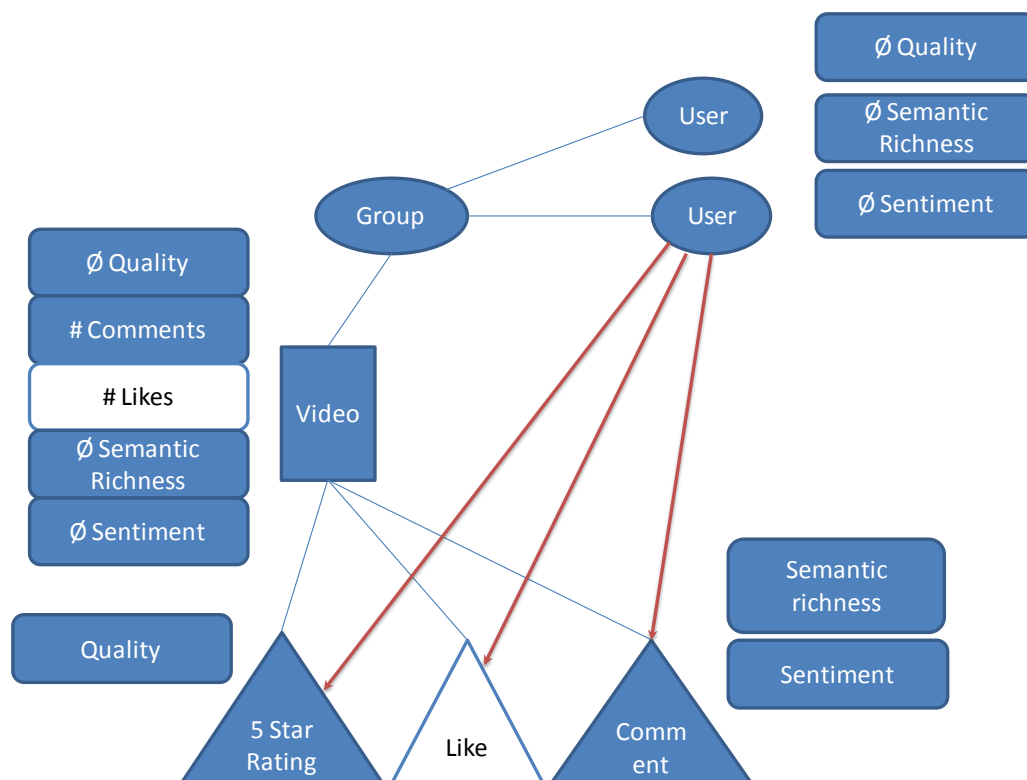


Figure 7 – Conceptual overview of entities, relationships and measures

Sentiment Analysis

To assign a sentiment value to a comment we use SentiWordNet (Baccianella et al., 2010) that assigns both, a positive and a negative value to each of the synsets from WordNet and their respective ranks. A synset is a set of words in which the words are considered semantically equivalent.

This approach provides a negative and a positive value for each comment, which builds upon the sum of the corresponding values for each word of the comment. From this sum, the comment is classified into one of three categories: negative (1), neutral (2) and positive (3). The ranges are set depending on the overall distribution among the comments from an early experiment and have to be adapted when real data is available.

Semantic Richness

The “Semantic Richness” values are computed by counting occurrences of keywords describing concepts of the field from a pre-defined keyword list, which is derived from the JuxtaLearn taxonomy (D2.1). Thus, the semantic richness value depends on the sum of the frequencies of the domain specific terms in a comment. Analogous to the sentiment value, we categorized the semantic richness values into three categories based on the overall distribution of technical vocabulary in all comments: no detected concepts mean a “low” richness (1), an average number of concepts mean a “medium” (2) richness and a number considerably above the average mean a “high” (3) semantic richness.

Quality

For the quality rating of the performance, we decided to use the Five-Star-Rating for the moment. We propose to aggregate to: a “negative” rating defined by one or two stars; a “neutral” rating is defined by three stars and four or five stars are considered a “positive” quality rating.

We have already run a proof of concept experiment (Daems et al., 2013), where 12 groups of mostly three students contributed 256 comments. The results (Daems et al., 2013) showed promising and interesting results w.r.t. providing performance indicators as

- the average semantic richness of the comments for a video seemed to be negatively correlated with average quality rating of the videos
- the number of comments and likes are (positively) correlated to semantic richness
- the percentage of positive comments of all comments for a video and average semantic richness of all comments of a video are negatively correlated
- the positive sentiment values and negative sentiment values of a single comment are (positively) correlated

Of course, the proposed measures and analysis methods need to be validated and adapted in experiments with more participants and a higher number of videos, but work as a starting point for a mechanism that highlights outstanding videos (either good or bad) to teachers and subsequently to other students within the learning analytics task in work package 6.

Ethical considerations

JuxtaLearn is a collaborative process, and its videos are intended for sharing. However, collaboration raises issues of privacy concerning who is watching the video, for how long after its production (Adams and Sasse, 1999), and who is allowed to access data meant to support the teacher in orchestrating the video performance process, and supporting

the students to reflect on their performance (both in the assessment sense and the drama play sense). In an educational setting, on large screen displays, not only students and staff, but perhaps visitors also watch - is that ethically permissible? Showing videos outside expected outlets might appear to students as an invasion of their privacy and teachers may need to determine which information their students perceive as private, who they want to see it, in which context and what it is going to be used for (Adams, 2000). When the students and their parents agreed to the video, how informed were they and perhaps they made assumptions as to the use of the video data, (Adams, 1999), for example, that the videos would be only for viewing, not for analysis of student behaviour.

Consent forms must state where JuxtaLearn video clips will be shown. It is not feasible for the project to determine where a video streamed from the web will be shown, if it is publicly available. If the videos were in a password-protected space for restricted viewing, then it would be possible to specify their showing only in the JuxtaLearn web space and other associated educational establishments

The UK 1998 Data Protection Act (DPA), says that data:

- must be obtained for a specified and lawful purpose
- shall not be processed in any manner incompatible with that purpose
- shall be adequate, relevant and not excessive for those purposes
- shall be kept up to date
- shall be kept for no longer than is necessary for that purpose
- must be processed in accordance with the data subject's rights
- must be kept safe from unauthorised access, accidental loss or destruction
- shall not be transferred to a country outside the European Economic Area unless that country has equivalent levels of protection for personal data.

However, there are exceptions if for example the data is completely anonymous. JuxtaLearn partner countries need to check local laws on data protection. See Deliverable D1.2, the JuxtaLearn ethics manual.

Who holds copyright and Intellectual Property Rights (IPR) of the JuxtaLearn video data? The data produced in the JuxtaLearn process will first be submitted to the teacher conducting the course in which the video has been created, and will then become accessible to all other students in the course, thus allowing peer-review, which in turn enables an improvement of reflection competencies. However, it is still open to debate as to whether only selected videos will then be submitted to the general pool of videos available for public display, or whether all videos by default will be in that pool. If different stages of publicity and therefore purposes are distinguished, there will be an impact on the questions for sustainability of the video data and related intellectual property issues.

4 Conclusion

Finally, we have an understanding of the orchestration factors and their relationships to the required JuxtaLearn framework. The JuxtaLearn process requires orchestrating around eight steps that participants can walk with the help of material objects in a particular environment negotiating meaning together.

The following table sums up the requirements. The stages particularly relevant to WP3, performance are shaded.

Table 4: Framework requirements

JuxtaLearn process	Material environment and objects required	People	Knowledge required	Comments on requirements, data management & ethics
Identify	Taxonomy and threshold concepts expressed in physical (paper) or electronic form (e.g. pencasts)	In order for the teachers to unpick the Threshold Concept, they need some support.	Teacher STEM knowledge of threshold concepts	Support might be a table or a form (see WP2 deliverables). It might be an electronic automated prompting system. It becomes an online system to scaffold breaking down the TC into stumbling blocks.
Demonstrate	Standard teaching activity & pedagogical palette Classroom or science laboratory	Teachers	Teacher teaching knowledge to create the pedagogical palette	
Interpret	Diagnostic quiz (electronic)			<ol style="list-style-type: none"> 1. An online scaffold that supports the teaching in linking quiz questions to stumbling blocks, should weight each question, highlighting stumbling blocks that the quiz doesn't address. 2. The processing of student answers needs to provide visual feedback to teachers and students, highlighting the stumbling blocks that trip students up. It needs to feedback on a class and individual student basis. Deliverable D2.4 will define this.
Perform	<ul style="list-style-type: none"> • Storyboard, script, video • In classroom and other school grounds 	Students;		Knowledge of dramatic techniques would be helpful, if available
Edit	Individual videos (clips), video	Teachers for guiding and directing students STEM awareness		Hardware, table tops, software help students to “communicate one’s motives to the rest of the group so they can be acknowledged and reflected on collectively in planning activities for further stages of the

JuxtaLearn process	Material environment and objects required	People	Knowledge required	Comments on requirements, data management & ethics
				video process” (Blazek and Hraňová, 2012 p164). Acknowledging and reflecting allows students to balance expectations and plans.
Share	Clips	Students; Data manager who has responsibility for storing retrievable videos for sharing;	Shared knowledge;	Disseminating the results will be via LSD, web space, in school corridor or halls. An important event in the PV process is the screening shared with the young people’s families and friends. Sharing also requires some means of sorting, searching and retrieving data, as well as managing data ethically so that only the right persons can access any.
Discuss	Web shared discussion space	Someone who monitors comments Students		See D6.1
Review	Diagnostic quiz	Students & teachers		This second diagnostic quiz will provide a similar visualisation to that at the interpret stage. Together with the learning analytics from WP5, it will measure improvements in students’ understanding and is a means of feeding back to the student to encourage reflection. Refer to D2.2.

In summary, this deliverable has

1. incorporated the pedagogy on threshold concepts and the pedagogical palette from WP2;
2. incorporated orchestration factors as mapped in WP3 D3.1;
3. anticipated incorporation of interaction mechanisms around public displays, including factors of curiosity and engagement characteristics;
4. integrated functionality for social network analysis of relevant public videos from WP6 task 6.3, supporting tagging and retrieval functions;
5. outlined a reflective performance framework for the JuxtaLearn process, setting out what material objects, and what people with what knowledge frame the process. D3.3 will specify these.

We have discussed and raised concerns about actions a teacher makes to orchestrate STEM learning through performance. We need to examine how the teacher orchestrates performance within ordinary classroom orchestration.

- How can a STEM teacher orchestrate a performance that requires creating videos to help a student group make sense of STEM threshold concepts?
- How can a teacher orchestrate what is needed to juxtapose understandings of STEM subjects with the challenges of creative video making?

Through use case workshops, WP3 will develop exemplars that identify how the STEM teacher can orchestrate participative performances that reflect, project, provoke and articulate. D3.4 will report on these workshops.

5 References

- ADAMS, A. (1999) Users' perception of privacy in multimedia communication. *CHI '99 Extended Abstracts on Human Factors in Computing Systems*. Pittsburgh, Pennsylvania, ACM.
- ADAMS, A. (2000) Multimedia information changes the whole privacy ballgame. *Proceedings of the tenth conference on Computers, freedom and privacy: challenging the assumptions*. Toronto, Ontario, Canada, ACM.
- ADAMS, A. & SASSE, M. A. (1999) Taming the wolf in sheep's clothing: privacy in multimedia communications. *Proceedings of the seventh ACM international conference on Multimedia (Part 1)*. Orlando, Florida, USA, ACM.
- BACCIANELLA, S., ESULI, A. & SEBASTIANI, F. C. L. (2010) SentiWordNet 3.0: An Enhanced Lexical Resource for Sentiment Analysis and Opinion Mining.
- BAUMEISTER, R. F. & LEARY, M. R. (1995) The need to belong: desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, 117.
- BECHKY, B. A. (2003) Object Lessons: Workplace Artifacts as Representations of Occupational Jurisdiction. *American Journal of Sociology*, 109, 720-752.
- BLAZEK, M. & HRAŇOVÁ, P. (2012) Emerging relationships and diverse motivations and benefits in participatory video with young people. *Children's Geographies*, 10, 151-168.
- BOLTON, G. M. (1984) *Drama as education : an argument for placing drama at the centre of the curriculum*, Harlow, Longman.
- BOUD, D., COHEN, R. & SAMPSON, J. (1999) Peer Learning and Assessment. *Assessment & Evaluation in Higher Education*, 24, 413-426.
- BRIGNULL, H., IZADI, S., FITZPATRICK, G., ROGERS, Y. & RODDEN, T. (2004) The introduction of a shared interactive surface into a communal space. *Proceedings of the 2004 ACM conference on computer supported cooperative work*. Chicago, Illinois, USA, ACM.
- CARLILE, P. R. (2002) A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development. *Organization Science*, 13, 442-455.
- CARLILE, P. R. (2004) Transferring, Translating, and Transforming: An Integrative Framework for Managing Knowledge Across Boundaries. *Organization Science*, 15, 555-568.
- CHANDLER, D. & MUNDAY, R. (2011) *A Dictionary of Media and Communication* [Online] Oxford University Press. Available at <http://www.oxfordreference.com.libezproxy.open.ac.uk/view/10.1093/acref/9780199568758.001.0001/acref-9780199568758-e-0154?rskey=81DImH&result=125&q=> (Accessed

- CIALDINI, R. B. (2005) What's the best secret device for engaging student interest? The answer is in the title. *Journal of Social & Clinical Psychology*, 24, 22-29.
- CORNEIL, M. K. (2012) Citizenship and Participatory Video. IN MILNE, E.-J., MITCHELL, C. & DE LANGE, N. (Eds.) *Handbook of Participatory Video*. AltaMira Press.
- CROSS, J. (2003) *Informal Learning - the other 80%* [Online]. Available at <http://www.internetttime.com/Learning/The%20Other%2080%25.htm> (Accessed Oct. 4, 2010)
- CSIKSZENTMIHALYI, M. (1990) *Flow : the psychology of optimal experience*, New York, Harper & Row.
- DAEMS, O., HAYA, P., MALZAHN, N., CASTELLANOS, J. & HOPPE, H. U. (2013) Evaluating the Interaction around Student-generated Videos in an Online Learning Environmen. *Workshop on Teaching Analytics C1 - Cyprus C3 - Proceeding of the 3rd international workshop on Teaching Analytics (IWTA-2013) at EC-TEL*.
- DERRY, S. J., PEA, R. D., BARRON, B., ENGLE, R. A., ERICKSON, F., GOLDMAN, R., HALL, R., KOSCHMANN, T., LEMKE, J. L., SHERIN, M. G. & SHERIN, B. L. (2010) Conducting Video Research in the Learning Sciences: Guidance on Selection, Analysis, Technology, and Ethics. *Journal of the Learning Sciences*, 19, 3-53.
- DEWEY, J. (1910) *How we think* [Online] Gutenberg. Available at <http://www.gutenberg.org/ebooks/37423> (Accessed 27/09/2013)
- DEWEY, J. (1933) *How we think*, Boston, D.C. Heath & Company.
- DILLENBOURG, P. (2008) Integrating technologies into educational ecosystems. *Distance Education*, 29, 127-140.
- DILLENBOURG, P. (2013) Design for classroom orchestration. *Computers & Education*, 69, 485-492.
- DILLENBOURG, P. & HONG, F. (2008) The mechanics of CSCL macro scripts. *International Journal of Computer-Supported Collaborative Learning*, 3, 5-23.
- DILLENBOURG, P. & JERMANN, P. (2010) Technology for classroom orchestration. *New Science of Learning: Cognition, Computers and Collaboration in Education*. Springer.
- DILLENBOURG, P., JERMANN, P., FISCHER, F., KOLLAR, I., MANDL, H. & HAAKE, J. (2007) Designing Integrative Scripts. *Scripting Computer-Supported Collaborative Learning*. Springer US.
- DILLENBOURG, P. & TCHOUNIKINE, P. (2007) Flexibility in macro-scripts for computer-supported collaborative learning. *Journal of Computer Assisted Learning*, 23, 1-13.
- DIX, A. & SAS, C. (2008) Public displays and private devices: a design space analysis. *Workshop on Designing and evaluating mobile phone-based interaction with public displays. CHI2008*,. Florence, 5th April 2008, CHI.
- DIX, A. & SAS, C. (2010) Mobile Personal Devices meet Situated Public Displays: Synergies and Opportunities. *International Journal of Ubiquitous Computing*, 1, 11-28.
- DIX, A., SAS, C., RAMDUNY-ELLIS, D., GILL, S. & HARE, J. (2008) Sociality, Physicality and Spatiality : touching private and public displays.
- DOOLIN, B. & MCLEOD, L. (2012) Sociomateriality and boundary objects in information systems development. *Eur J Inf Syst*, 21, 570 -586.
- DÖRING, N. (2004) Sozio-emotionale Dimensionen des Internet. IN MANGOLD, R., VORDERER, P. & BENTE, G. (Eds.) *Lehrbuch der Medienpsychologie*. Hogrefe.
- DOW (2012-07-20) Annex I - "Description of Work" Juxtapositioned reflective performance enabling science and technology learning. 2012-07-20 ed.
- EKEOCHA, J. O. & BRENNAN, S. E. (2008) Collaborative recall in face-to-face and electronic groups. *Memory*, 16, 245-261.
- FESTINGER, L. (1954) A theory of social comparison processes. *Human Relations*, 7, 117-140.
- FORSYTH, R., CARROLL, K. & REITANO, P. (2009) Illuminating everyday realities: The significance of video methods for social science and health research. *INTERNATIONAL JOURNAL OF MULTIPLE RESEARCH APPROACHES*, 3, 214-217.
- FRANCO, A. L. (in press) Rethinking Soft OR interventions: Models as boundary objects. *European Journal of Operational Research*.

- FULLER, D. & MAGERKO, B. (2011) Shared mental models in improvisational theatre. *Proceedings of the 8th ACM conference on creativity and cognition*. Atlanta, Georgia, USA, ACM.
- GOLDSMITH, R. (2009) *Participation - key areas of debate* [Online]. Available at <http://www.catchermedia.co.uk/inter-act/inter-act1> (Accessed 22/01/2012).
- GOODMAN, L. (2009) To Camera - imagine a world. *Inter.ACT*.
- HAAS, S., TRUMP, T., GERHARDS, M. & KLINGLER, W. (2007) Web 2.0: Nutzung und Nutzertypen : Eine Analyse auf der Basis quantitativer und qualitativer Untersuchungen. *Mediaperspektiven*, 4, 215-222.
- HALL, S. (1973) Encoding and Decoding in the Television Discourse. *CCCS stencilled paper 7*. University of Nirmingham.
- HARRER, A. & MALZAHN, N. C. (2006) Bridging the gap-towards a graphical modeling language for learning designs and collaboration scripts of various granularities. *Advanced Learning Technologies Sixth International Conference*
- HARRER, A. G. (2000) *Unterstützung von Lerngemeinschaften in verteilten intelligenten Lehrsystemen [Supporting learning groups in shared virtual systems]*, Doctoral dissertation, Technische Universität München, Universitätsbibliothek
- HARRIS, S. J. (2013a) The film stars that will live for ever. *Daily Telegraph*. London, Y.
- HARRIS, S. J. (2013b) *Rosebud Sleds and Horses' Heads: 50 of Film's Most Evocative Objects - an Illustrated Journey*.
- HAW, K. & HADFIELD, M. (2011) *Video in Social Science Research: Functions and Forms*.
- HENDERSON, K. (1991) Flexible Sketches and Inflexible Data Bases: Visual Communication, Conscription Devices, and Boundary Objects in Design Engineering. *Science, Technology, and Human Values*, 16, 448-473.
- JERMANN, P., SOLLER, A., MÜHLENBROCK, M. & OTHERS (2001) From mirroring to guiding: A review of the state of art technology for supporting collaborative learning. *C3 - Proceedings of the European Conference on Computer-Supported Collaborative Learning EuroCsl-2001*. . Maastricht, The Netherlands.
- JEWITT, C. (2012) An introduction to using video for research. *Working Paper*. National Centre for Research Methods (ESRC).
- JONES, A. (1995) Constructivist learning theories and IT. IN EINON, G., HEAP, N., MACKAY, H., MASON, R., THOMAS, R. & OPEN UNIVERSITY THD204/COURSE READER. (Eds.) *Information technology and society : a reader*. London, Sage in association with the Open University.
- KATZ, E., BLUMLER, J. G. & GUREVITCH, M. (Eds.) (1974) *Utilization of mass communication by the individual*, Beverly Hills, Sage Publications.
- KIMMERLE, J., MOSKALIUK, J. & CRESS, U. (2009) Individual Learning and Collaborative Knowledge Building with Shared Digital Artifacts *International Journal of Human and Social Sciences*, 9.
- KINDEM, G. & MUSBURGER, R. B. (2001) *Introduction to media production : from analog to digital*, Boston, Mass. ; Oxford, Focal Press.
- KOLLAR, I., FISCHER, F. & HESSE, F. (2006) Collaboration Scripts - A Conceptual Analysis. *Educational Psychology Review*, 18, 159-185.
- KRAJCIK, J. S., BLUMENFELD, P. C., MARX, R. W. & SOLOWAY, E. (1994) A collaborative model for helping middle grade science teachers learn project-based instruction. *The elementary school journal*, 483-497.
- KRÄMER, N. C. & WINTER, S. (2008) Impression Management 2.0. *Journal of Media Psychology: Theories, Methods, and Applications*, 20, 106-116.
- LEIJEN, Å. L., VALTNA, K., LEIJEN, D. A. J. & PEDASTE, M. (2012) How to determine the quality of students' reflections? *Studies in Higher Education*, 37, 203-217.
- LEVINA, N. & VAAST, E. (2005) The emergence of boundary spanning competence in practice: implications for implementation and use of information systems. *MIS Quarterly*, 29, 335-363.
- MAANINEN-OLSSON, E. & MÜLLERN, T. (2009) A contextual understanding of projects--The importance of space and time. *Scandinavian Journal of Management*, 25, 327-339.

- MAGERKO, B., MANZOUL, W., RIEDL, M., BAUMER, A., FULLER, D., LUTHER, K. & PEARCE, C. (2009) An empirical study of cognition and theatrical improvisation. *Proceedings of the seventh ACM conference on Creativity and cognition*. Berkeley, California, USA, ACM.
- MAIER, N. R. F. (1970) *Problem Solving and Creativity; In Individuals and Groups*.
- MALZAHN, N., POKRANDT, M., HOPPE, H. & C., U. (2008) Extending a Learning Design Editor with a Monitoring Component. *Proceedings of the the International Conference on Computers in Education* Taipei Taiwan.
- MAYER, R. E. (2004) Should there be a three-strikes rule against pure discovery learning? *American Psychologist*, 59.
- MEDNICK, S. (1962) The associative basis of the creative process. *Psychological Review*, 69, 220-232.
- MICHELIS, D. & MULLER, J. (2011) The Audience Funnel: Observations of Gesture Based Interaction With Multiple Large Displays in a City Center. *International Journal of Human-Computer Interaction*, 27, 562-579.
- ORLIKOWSKI, W. J. (2006) Material knowing: the scaffolding of human knowledgeability. *European Journal of Information Systems*, 15, 460-466.
- ORLIKOWSKI, W. J. (2007) Sociomaterial Practices: Exploring Technology at Work. *Organization Studies* (01708406), 28, 1435-1448.
- PALINCSAR, A. S. & BROWN, A. L. (1984) Reciprocal Teaching of Comprehension- Fostering and Comprehension-Monitoring Activities. *Cognitions and instruction*, 1, 117-175.
- PEA, R. D. (2004) The social and technological dimensions of scaffolding and related theoretical concepts for learning, education, and human activity. *The Journal of the Learning Sciences*, 13, 423-451.
- PREECE, J. & SCHNEIDERMAN, B. (2009) The Reader-to-Leader Framework: Motivating Technology-Mediated Social Participation. *AIS Transactions on Human-Computer Interaction* 1, 13-32
- REA, P. W. & IRVING, D. K. (2010) *Producing and Directing the Short Film and Video*, Elsevier, Focal Press.
- REIMER, T. (2001) Kognitive Ansätze zur Vorhersage der Gruppenleistung. Distraction, Kompensation und Akzentuierung. *Zeitschrift für Sozialpsychologie*, 32, 107-128.
- SCANLON, E., ANASTOPOULOU, S. & KERAWALLA, L. (2012) Inquiry learning reconsidered: contexts, representations and challenges. IN LITTLETON, K., SCANLON, E. & SHARPLES, M. (Eds.) *Orchestrating Inquiry Learning*. London and New York, Routledge.
- STAHL, G. (2006) *Group Cognition: Computer Support for Building Collaborative Knowledge*, Cambridge: The MIT Press, Citeseer.
- STAR, S. L. & GRIESEMER, J. R. (1989) Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science* (Sage), 19, 387-420.
- STRÄFLING, N., GANSTER, T., KRÄMER, N. C., GRUNDNIG, S. A., MALZAHN, N. & HOPPE, U. (Eds.) (2011) *FoodWeb 2.0. Entwicklung, Erprobung und Evaluation von Web 2.0 Technologien zur Stärkung von Bildung und Innovation*, Dresden, September 2011., GMW -WissensGemeinschaften 2011.
- STREITZ, N., PRANTE, T., RÖCKER, C., VAN ALPHEN, D., MAGERKURTH, C., STENZEL, R. & PLEWE, D. (2003) Ambient Displays and Mobile Devices for the Creation of Social Architectural Spaces: Supporting informal communication and social awareness in organizations. IN O'HARA, K., PERRY, M., CHURCHILL, E. & RUSSELL, D. (Eds.) *Public and Situated Displays Social and Interactional Aspects of Shared Display Technologies*. Dordrecht, Kluwer Publishers.
- THE FUN THEORY (2009) *Piano Staircase* [Online]. Available at <http://www.thefuntheory.com/> (Accessed 22/022013).
- TIEBEN, R., BEKKER, T. & SCHOUTEN, B. (2011) Curiosity and interaction: making people curious through interactive systems. *Proceedings of the 25th BCS Conference on Human-Computer Interaction*. Newcastle-upon-Tyne, United Kingdom, British Computer Society.
- TOPPING, K. J. (2005) Trends in peer learning. *Educational Psychology Review*, 25, 631-645 (25th anniversary edition).

-
- VAN DEN EYNDEN, V., CORTI, L., WOOLLARD, M., BISHOP, L. & HORTON, L. (2011) Managing and sharing data. IN UK DATA ARCHIVE (Ed.). Colchester, UK, University of Essex.
- VAN JOOLINGEN, W. R. & DE JONG, T. (1991) Supporting hypothesis generation by learners exploring an interactive computer simulation. *INSTRUCTIONAL SCIENCE*, 20, 389-404.
- VOGEL, D. & BALAKRISHNAN, R. (2004) Interactive public ambient displays: Transitioning from Implicit to Explicit, Public to Personal, Interaction with Multiple Users. *Proceedings of the 17th annual ACM symposium on User interface software and technology - UIST*. New York, USA, ACM Press.
- WAGNER, B. J. (1979) *Dorothy Heathcote*.
- WHITE, S. A. (Ed.) (2003) *Participatory video : images that transform and empower*, New Delhi ; Thousand Oaks, CA., Sage.
- WOOD, L. & OLIVIER, T. (2011) Video production as a tool for raising educator awareness about collaborative teacher-parent partnerships. *Educational Research*, 53, 399-414.